THE EFFECTIVENESS OF A SPLINT PROGRAMME IN PREVENTING THE DETERIORATION OF ALREADY EVIDENT SWAN NECK AND BOUTONNIERE DEFORMITIES IN PATIENTS WITH RHEUMATOID ARTHRITIS

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CONTENTS

ABSTRACT

The aim of this study was to establish whether a splint programme is effective in preventing the deterioration of already evident swan neck and boutonniere deformities in rheumatoid arthritis (RA). A randomised clinical trial was done on 34 RA patients with swan neck and 34 RA patients with boutonniere deformities. The literature revealed that several factors such as age, gender, socio-economic status, time after onset of the illness and lifestyle could influence results. Care was taken to allocate, as far as possible equal numbers of patients with these attributes to the experimental and control groups.

It became clear from the literature that swan neck and boutonniere deformities could manifest themselves in different forms and stages or grades of deterioration. Various splints to halt the downward spiral of the deformity were recommended, without proper scientific verification, by the authors. No specifications as to which splint was recommended for which form or grade of deformity or instructions for wearing of the splints were included.

For the study the PIP hyperextension splint and the three-point-PIP extension splint was chosen for the swan neck and boutonniere deformities respectively. Patients were followed up for one year.

Results were marginally positive for the prevention of swan neck deformities by the hyperextension splint programme, but results for the three-point PIP extension splint programmes were negative for grade I boutonniere deformities. Loss of flexor muscle strength was evident in almost all the groups (experimental and control) but more so for grade I swan neck and grade I boutonniere deformities.

The variability of measurements were found to be large. Many possible sources of variation were identified, which included biological differences between people, different courses the illness could take and a weak test-retest reliability of some goniometer measurements. This fact and the relatively small sample subgroups caused some results to be not significant on the 5% level.

From the significant findings, and other not significant tendencies that were too persistent to ignore, linked to the different manifestations and grades of swan neck and boutonniere deformities, recommendations were made. These suggestions will have to be tested by experimentation.

LIST OF TABLES

LIST OF FIGURES

LIST OF FLOW DIAGRAMS

LIST OF GRAPHS

DEFINITION OF TERMS

EFFECTIVENESS:

An EFFECTIVE treatment does more good than harm in those to whom it is offered. Effectiveness is established by offering a treatment or program to patients and allowing them to accept or reject it as they might ordinarily do. If a treatment is found to be ineffective, it may be due to lack of EFFICACY, lack of patient acceptance or both. (FLETCHER, FLETCHER and WAGNER, 1982, 146)

EFFICACY:

An EFFICATIOUS treatment is one that does more good than harm to those who receive it. Efficacy is established by restricting patients in a study to those who will cooperate fully with medical advice. (FLETCHER, FLETCHER and WAGNER, 1982, 146)

SPLINT PROGRAMME:

A SPLINT PROGRAMME consists of the presciption of the splint, careful consideration of the fitting of the splint; education of the patient in what is expected of him or her in wearing the splint, caring for the splint and the bodyparts in contact with the splint as well as follow up to reevaluate the necessity of the splint. (Own definition)

RANDOM ALLOCATION:

A procedure for assigning treatments to patients in such a way that all possible assignments of treatments to patients are equally likely within the constraints of the experimental design. (MAUSNER and KRAMER, 1985, 197)

STRATIFICATION:

A process by which the researcher makes sure before randomization that at least some of the most important characteristics known to be associated with the outcome will appear equally in experimental and control groups. (Adapted from ANDERSON D R , SWEENEY D J and THOMAS A L, 1981, 200-202)

RANDOMIZED CLINICAL TRIAL:

An investigation in which identical cohorts of individuals allocated (preferably by randomization) by the investigator are, and are not exposed to an experimental manoevre and followed up for the outcomes of interest. (FLETCHER, FLETCHER and WAGNER, 1982, 138)

SENSITIVITY:

Sensitivity of a measurement is defined as the proportion of subjects with the disease (or condition of interest) who have a positive test for the disease (or condition of interest). A sensitive test will rarely miss people with the disease. (FLETCHER, FLETCHER and WAGNER, 1982, 46)

SPECIFICITY:

Specificity is the proportion of subjects without the disease who have a negative test. A specific test will rarely misclassify people without the disease as diseased. (FLETCHER, FLETCHER and WAGNER, 1982, 46)

FALSE POSITIVES:

A FALSE POSITIVE result of a test is an incorrect test result which occurs when a test measures the individual as having a disease or condition of interest (i.e. testing positive) when in fact the individual does not have the disease or condition of interest. (Adapted from FLETCHER, FLETCHER and WAGNER, 1982, 43)

BIAS:

Any process at any stage of inference which tends to produce results or conclusions that differ systematically from the truth. (SACKETT, 1979)

THE HAWTHORNE EFFECT (HALO EFFECT):

The Hawthorne effect (or halo effect) is the tendency for people to change their behaviour because they are the target of special interest and attention in a study, regardless of the specific nature of the intervention they might be receiving. (FLETCHER, FLETCHER and WAGNER, 1982, 134)

COMPLIANCE:

Compliance is the extent to which patients follow medical advice. (FLETCHER, FLETCHER and WAGNER, 1982, 146)

STRUCTURED INTERVIEW QUESTIONNAIRE:

An questionnaire completed by an interviewer by asking the interviewee a predetermined set of questions in a specified manner and recording the answers according to a specified code or system. (Own definition)

CONFOUNDING VARIABLE:

A factor that distorts the apparent magnitude of the effect of a study factor on risk. Such a factor is a determinant of the outcome of interest and is unequally distributed among the exposed and the unexposed. (LAST J M, 1983, 21)

POWER:

Relative frequency with which a true difference of specified size between populations would be detected by the proposed experiment or test. (LAST J M, 1983, 81)

RHEUMATOID ARTHRITIS:

A chronic systemic disease primarily of the joints, usually polyarticular, marked by inflammatory changes in the synovial membranes and articular structures and by atrophy and rarefaction of the bones. (TAYLOR E J, 1988, 147)

BOUTONNIERE DEFORMITY:

A deformity of the finger characterized by flexion of the proximal interphalangeal joint and hyperextension of the distal joint; called also a buttonhole deformity. (TAYLOR, 1988,438)

SWAN NECK DEFORMITY:

A finger deformity in which the proximal interphalangeal joint is hyperextended and the distal interphalangeal joint is flexed. (TAYLOR, 1988, 438)

SPLINT:

A rigid or flexible appliance used to maintain in position a displaced or movable part or to keep in place and protect an injured part. (TAYLOR, 1988, 1565)

DYNAMIC SPLINT:

A support or protective apparatus for the hand or any part of the body which also aids in initiating and performing motion of that part or adjacent parts and assists in dealing with the forces resulting from the action, thus assisting in those motions necessary to perform the activities of daily living. (TAYLOR, 1988, 1565

STRAIN:

An overstretching or overexertion of some part of the musculature; excessive effort or undue exercise. (TAYLOR, 1988, 1587)

CHAPTER 1

INTRODUCTION:

1. THE PROBLEM:

Rheumatoid Arthritis (RA) is a disease which affects not only joints and bones but also other soft tissue (Burke, 1984). The hand is a part of the body where the effect of soft tissue involvement is clearly demonstrated. As the hand is especially rich in synovial membranes, tendons, small muscles, fibrous bands, sheaths and ligaments, it is therefore vulnerable to the ravages of RA. The end result of the destructive work of RA to these structures in the hand is the upsetting of the delicate balance in the hand, as explained by Pretorius. (1988, p.25). This contributes to the development of deformities of the hand, of which the swan neck and boutonniere deformities are two of the very common ones affecting the proximal interphalangeal joints (PIP) (Tubiana and Toth, 1984).

Treatment suggested for these deformities includes splinting (Convery and Minteer, 1974; Flatt, 1983, p.46; Ellis, 1984). The recommendations for splinting however are currently non-specific as to which splints are indicated under which circumstances (Philips, 1989). No research has been done on their effectiveness either. As Merrit has concluded, "Their scientific application (i.e. splints for RA) is not limited so much by technology as by the lack of controlled clinical studies of their efficacy." (Merrit, 1987)

The occupational therapist (OT) prescribing splints as advised for these deformities has to give the patient an indication of the success rate of the splint in preventing the deformity, because the benefits are not

experienced immediately by the patient. Contrary to resting splints designed to alleviate pain in the RA hand (Philips, 1989) the splints designed for the swan neck or boutonniere deformities may not provide the patient with pain relief. The splints, being preventative in design, might also not show dramatic results within a week or two. Positive results of wearing the splint will only be evident by the lack of deformity after a suitable lapse of time. The patient may therefore lose his or her motivation to wear the splint as prescribed, if the therapist is unable to reassure the patient of the splint's benefits. It is therefore imperative that a success rate be established for the use of these splints.

2. AIM AND OBJECTIVES OF THE STUDY:

The aim of this study is to establish whether a splint programme is effective in preventing the deterioration of already evident swan neck and boutonniere deformities in patients with RA.

OBJECTIVES:

(1) To establish a theoretical basis for the prevention of swan neck deformities in RA patients through the medium of splinting.

(2) To establish a theoretical basis for the prevention of boutonniere deformities in RA patients through the medium of splints.

(3) To select an appropriate splint for each one of the two deformities and to design a splint programme based on suggestions from the literature.

(4) To establish the factors that may influence the development of deformities and appropriate ways of measuring them.

(5) To find a reliable and valid instrument or instruments to measure the deformity.

3. HYPOTHESIS:

Fingers of patients with RA which are treated by means of a specific splint programme will show less worsening in grade of swan neck or boutonniere deformity than fingers of patients not treated with the splint programme.

4. METHODS OF INVESTIGATION:

4.1 STUDY STRUCTURE:

An experimental study, namely a randomised clinical trial (Mausner and Kramer, 1985, p.197) was used to compare an experimental group (A) receiving splint treatment for swan neck and boutonniere deformities with a control group (B) not receiving the splint treatment. Both groups A and B were being treated similarly in every other respect in the usual running of the clinic.

4.2 THE REFERENCE POPULATION:

(1) Patients positively diagnosed as having RA.

(2) Swan neck and boutonniere deformities which have originated from RA.

(3) Grades 1 and 2 deformities. (See page 6)

(4) The patient must have been prepared to be followed up for at least a year at Tygerberg Rheumatology Clinics.

Because Tygerberg Hospital is a teaching hospital, the rheumatological cases referred to it may be the more complicated ones and therefore not fully representative of the general population of RA patients.

(5) The patient must have given his or her consent to the trial.

4.3 EXPERIMENTAL POPULATION:

(1) Consecutive patients with RA seen at the Rheumatology clinics at Tygerberg Hospital two days per week were screened for inclusion in the study according to the above criteria. Clinics were held regularly, excluding certain holidays and examination days of medical students. This included two clinics, one on a Tuesday and one on a Thursday, both conducted by the same team, except for the occupational therapist. The two participating occupational therapists each assumed responsibility for a clinic.

(2) Screening of patients visiting the Thursday clinic was started in January 1989 and screening at the Tuesday clinic six months later.

(3) In a previous study (Du Toit et al, 1989) conducted at the same clinics, 56% of patients seen consecutively were diagnosed as having RA. At the current time 580 patients were registered at the clinics, which left an estimate of 325 patients with RA. If 60% of patients with RA had either one of the deformities, a potential number of 195 people with deformities would have been available for study. Assuming a similar prevalence of swan neck and boutonniere deformities as well as grade of deformity, an estimate of 32 patients per grade per deformity seemed possible.

(4) A finger of each patient was selected for inclusion in the study. Precedence was given to the non dominant hand to interfere as little as possible with the activities of the patient's daily life and preferably not the little finger, as it is extremely difficult to splint it when the hand is small.

See Chapter III for results of sampling.

4.4 RANDOM ALLOCATION TO EXPERIMENTAL AND CONTROL GROUPS:

(1) After selection the patients were randomly allocated to the experimental and control groups by using a "Balanced Block Stratified Random Allocation". (Zelen, 1974) Stratification was done according to the grade of deformity and the clinic where the patient was treated. Both factors could have biased results. Different grades of deformity might have unequal prognoses and occupational therapy provided by alternate therapists (See 4.3 (1)) might vary.

(2) Provisional randomization was obtained by using a table of random numbers. Equal numbers led to inclusion in the experimental group whilst unequal numbers were added to the control group.

(3) Through random allocation more patients can by chance be included in either the experimental or control groups of the subgroups of grade of deformity and clinic attended. If the number of patients in either the experimental or control subgroups in the sub groupings differed by two (2), the researcher must reverse the provisional allocation. It is by this system that the "balancing" of the numbers in the "Balanced Block Stratified Random Allocation" was done.

(See chapter III for results of allocation to groups.)

4.5 MEASUREMENT:

4.5.1 INSTRUMENTS FOR GRADING OF DEFROMITIES:

Grading of the swan neck and boutonniere deformities was documented well by several authors (Welsh, 1977; Firpo 1985; Swanson, 1985) showing strong similarities. (For a detailed discussion, see Chapter II) The system of grading used in this study is summarized in TABLES 1 and 2.

TABLE 1: GRADING OF SWAN NECK DEFORMITIES:

GRADE	SIGNS
GRADE I	No restriction on passive range of movement (ROM) of Metacarpophalangeal (MP) or proximal interphalangeal (PIP) joints. Slight hyperextention of PIP joints or lack of normal flexion position at rest.
GRADE II	The above coupled with flexion of the distal interphalangeal joints (DIP) plus any of the following signs: Intrinsic tightness Snapping of lateral bands of extensor expansion from dorsal to lateral. Soft tissue involvement evident.
GRADE III	PIP joints stiff in extension. Any passive movement difficult to achieve.

TABLE 2: GRADING OF BOUTONNIERE DEFORMITIES:

GRADE	SIGNS
GRADE I	Mobile PIP joint, but assuming flexion position if asked to stretch hand. Retinacular test negative.
GRADE II	PIP joint still fairly mobile with some extensor lag. Retinacular test positive. Soft tissue involvement evident
GRADE III	PIP joints stiff in flexion. Passive extension very difficult

4.5.2. SOURCES OF VARIATION IN GRADING OF DEFORMITIES:

(1) BIOLOGICAL:

Very little biological variation in the grade of deformity is expected from day to day. That is, a change in grade of deformity would indicate a genuine change in the deformity and is not expected to be reversed the next day.

(2) INSTRUMENT:

The 'instrument' used is the grading system above. Very specific tests can be administered to distinguish between a grade one and grade two deformity. (For detailed discussion, see Chapter II) The distinction between grades two and three was made solely on a lack of passive movement. This gives rise to a variation in interpretation.

(3) SITUATION:

Structuring of the situation in which measurements are made, is not a major source of variation in this instance, provided that the therapist is able to see and move the patient's joints freely. The Tuesday and Thursday clinics have similar surroundings and furniture to accomplish this.

(4) OBSERVER:

Observations as to grade of deformity should stay constant, if the system is used meticulously. It is not possible to 'blind' the observers as to which patient is in the experimental or control groups, because the splint programme is provided by the same therapist. The therapist is however not forced to see the previous results before grading, because a new form is used every day. She can however look up previous results, but is urged not to change results accordingly.

Interrater reliability could be affected by two observers interpreting phrases like "lack of normal flexion position in rest" and 'passive movement difficult to achieve" (see Tables 1 and 2) differently. To counteract this potential bias, a full days training of the second therapist was done, including demonstration, switching of roles and double checking each

others measurements.

4.5.3 SENSITIVITY AND SPECIFICITY OF GRADING:

The grading of deformities seems to be specific (Fletcher et al, 1982, p.46), especially in indicating a deterioration from grade 1 to grade 2 deformity. False positives were however deemed possible in distinguishing between a normal lax PIP joint and a very slight grade 1 swan neck, thus identifying a normal finger as having a swan neck deformity. The attention of the observers was however drawn to the fact that a distinction between the normal lax joint and a slight swan-neck deformity can be made if the PIP joint's position of rest is observed. The normal PIP joint rests in flexion, but in the case of a swan neck deformity in extension. It is also possible to detect a grade 1 swan neck by comparing fingers of the same hand. It is usually very clear if one finger rests in a less flexed position as the other fingers. False negatives can therefore be limited to a large extent. The grading system is regarded as also sensitive in picking up deterioration from grade to grade.

Deterioration of deformities within the grade is however not picked up by this categorisation. A more sensitive test to detect small differences within the grade is therefore imperative.

4.5.4 INSTRUMENT TO MEASURE WITHIN GRADE DIFFERENCES:

Because passive range of motion of the PIP joint is part of the grading sytem (See Tables 1 and 2), it is postulated that a change in passive ROM of the PIP joints is indicative of a changing deformity.. Active and passive range of flexion and extention of the PIP joints is measured using an ENRAF (R) digital goniometer.

4.5.5 SOURCES OF VARIATION IN GONIOMETER MEASUREMENTS:

(1) BIOLOGICAL:

Rheumatoid arthritis is marked by a course of 'flare-ups' and remissions which go hand in hand with synovial swelling of the small joints of the hands (Harris, 1985, p.918-921). Great biological variation due to variations in the pathology is possible, especially in joint mobility.

Biological variation due to differences in individuals is reported to be vast as far as ROM is concerned (Smith, 1982). Cantrell and Fisher (1982) established the reliability of goniometer readings on the electronic goniometer and found differences in people's PIP extension limited to eight standard deviations from the mean and PIP extension to twelve standard deviations from the mean. In order to circumvent this possible additional source of variation the gain or loss of movement will be used, thus comparing each person's measurement with his own previous measurement as opposed to contrasting the mean measurement of the control group with the mean measurement of the experimental group.

The ENRAF goniometer is presumably less accurate than an electronic goniometer. A pilot study, using the ENRAF goniometer, was done on 30 female students,. Results indicated a standard deviation from the mean between 3.1 and 8.5 in PIP joint mobility. This compares favourably with the results of the electronic goniometer. (See Chapter III for details).

Test-retest reliability of the electronic goniometer (Cantrell and Fisher, 1982) was found to reach a maximum of five degrees error and at average one degree error.

(See Chapter III for results on ENRAF goniometer test-retest and interrater reliability)

(2) INSTRUMENT:

The ENRAF goniometer should be greased at its joint to ensure smooth movement. Once the goniometer has been submersed in water it should be lubricated again. The ENRAF goniometer's calibration is marked in distances of five degrees. It is thus very difficult to accurately measure within five degrees.

The ENRAF goniometer is aligned to the joint by placing it on the dorsal or ventral surface of the first and second phalanges. The joint of the goniometer does therefore not coincide with the midpoint of the joint and theoretically does not reveal the true value of the joint range. However, because gain or loss in range is the parameter measured, if the same method is used consistently, a valid indication of improvement in or worsening of the joint mobility can be reached.

(3) SITUATION:

The importance of a constant situation for measurement is stressed by Bradley (1982), including factors such as temperature, time of day, whether joints were warmed up by passive movement before measurement and stabilisation of the arm at an appropriate height whilst measurment is done. The same cubicles and furniture were used without changing their lay-out in the two clinics. The temperature of the hospital is controlled centrally. The time at which measurement was taken could not be controlled by the observer, because the whole morning must be utilised to fit all assessments in. The therapist always took the measurement twice. The first movement of the joint was done actively by the patient, and then repeated for a reading. Then the joint was moved passively by the therapist, a reading was taken and then repeated for the final reading, which was usually

fractionally larger. By the time the final passive range of movement was measured, the joints were warmed up sufficiently, without causing strain on inflamed joints.

(4) OBSERVER:

End digit preference bias (Sackett,1979) is possible, because the goniometer is calibrated to five degrees. As long as both observers systematically record the reading as a multiple of five, the interrater and test-retest reliability will not be adversely affected.

Other aspects of observer variation were dealt with in the same way as that of "grading of deformity".

4.5.6 MEASUREMENT PROGRAMME:

Both the experimental and control groups were assessed at the outset as well as at the termination of the study. In addition the patients were measured at regular two- to three-month follow-up visits to the clinic for the following reasons:

(1) if a patient was lost for any reason, data of state of deformity was available for interpretation.

(2) development of deformity over time could be verified by the progressive loss of ROM and false positives could be ruled out if a result was not backed by a follow-up result.

(3) contact was maintained also with the control group to guard against a halo effect. (Fletcher, 1982) The experimental group's splints were checked regularly and they were motivated to keep on wearing the splint. The control group got the same amount of attention as the

experimental group and this was achieved by these regular measurements.

4.5.7 ADDITIONAL MEASUREMENTS NEEDED TO OVERCOME BIASES:

Careful notation of dates of measurement and accompanying data of change of medication, treatment by other team members, flare-ups and remissions of the illness as well as the compliance of patients wearing the splints were made.

A coded form was developed for the therapist to fill in baseline data at each measurement (See Appendix 1).

A structured interview questionaire was used by the therapist to establish the compliance of the patient in wearing the splint (See Appendix 1).

The level of strain the patient's hands were subjected to on a regular basis, was measured by an instrument developed in a pilot study. (See Appendix 2). A comprehensive list of activities a person performs with his or her hands was arrived at by piloting a list among fellow Occupational therapists. All duplications of identical activities or movement patterns left out were corrected. All activities were analysed as far as types of grasp, range of movement and power of grasp were concerned. This was piloted on 14 normal individuals arriving at strain levels for the normal individual. Compared to 27 patients with RA the instrument showed that the RA patients put less strain on their hands than the normal subjects and the largest difference between the RA and normal group was in the four strenuous activity categories. It is evident that differences in strain on the individual patient's hands could be adequately estimated by this instrument. (See Chapter III for results of pilot study)

4.6 THE SPLINT PROGRAMME:

4.6.1 THE SPLINTS:

For the SWAN NECK deformity a static thermoplastic splint, called the "donut splint" by Flatt (1983, p.48) were used. The splint allows flexion but restricts extension of the PIP joint (see Chapter II, p.46).

For the BOUTONNIERE deformity a static adaptable wire splint was used (Callahan and McEntee,1986). The design is based on the Capener (Nalebuff and Millender, 1975b), but is less bulky and allows the patient to serially stretch his or her own PIP joint by applying three point pressure (see Chapter II, p.58).

4.6.2 INSTRUCTIONS TO PATIENTS:

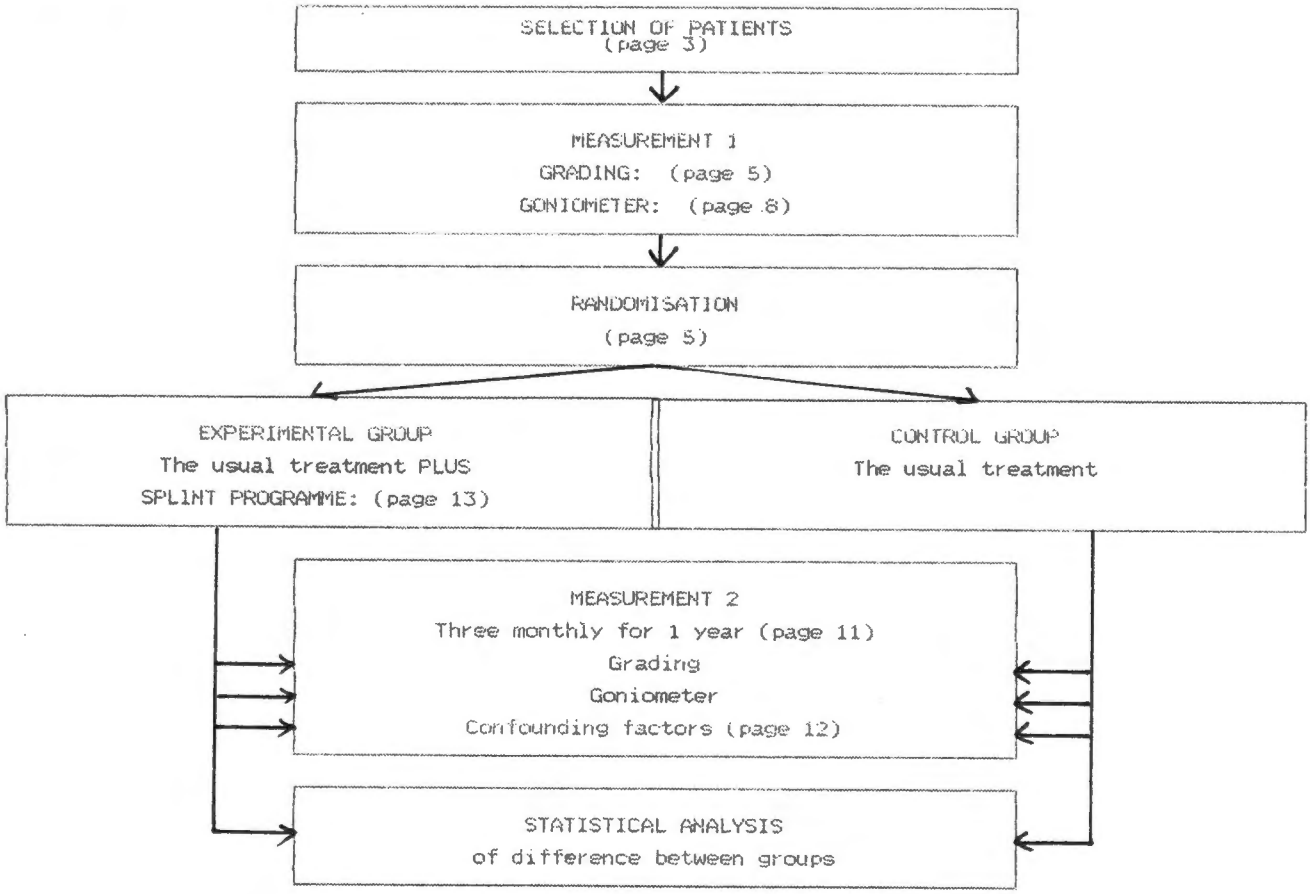
Patients practiced putting on and taking off the splint straight after manufacture until it was positioned correctly in relation to the joints. Patients who were supplied with the Boutonniere splint were given instructions and practice in how to apply some stretch at the PIP joint but still maintain a comfortable position of the joint.

Patients were instructed to wear the splint eight out of 24 hours every day. No restrictions were placed on time of day or night. It was stressed that an uncomfortable splint is not acceptable, and that the patient must come back and ask for another one, if it was not comfortable.

Patients were taught about the care of the splint, be it in cleaning of the low temperature thermoplastic splint or taking care not to upset the angles of the bent wire.

SUMMARY:

The study was performed along the methodological framework of a randomized clinical trial. The steps which were followed are outlined in the following diagram:



CHAPTER II

INTRODUCTION:

In this chapter pertinent current literature will be discussed. This will include a broad outline of the prevalence of rheumatoid arthritis (RA) and its natural course and prognosis. A description of the effect the illness could have on a patient's joints, will introduce the discussion on the manifestation and development of the swan neck and boutonniere deformities in the RA hand. Preventative treatment, as suggested in the literature, including the use of splints, will be debated subsequently. The problem of low compliance in wearing of splints, will also receive attention. This chapter will be concluded by a discussion of measurement of change in deformity.

1. RHEUMATOID ARTHRITIS:

1.1 PREVALENCE:

Prevalence is the total number of old and new cases of a disease per 1000 of the population, compared to incidence, which is the total number of new cases per time per 1000 of the population (Mausner, 1985, p.44).

Rheumatoid arthritis is a chronic disease and, although debatable, not life threatening. It is therefore appropriate that the prevalence rather than the incidence of the disease should be studied, to obtain an idea of the extent of the demands that this illness makes on the health providing systems. The prevalence of rheumatoid arthritis was estimated to be in the range of 3/1000 to 15/1000, according to reports from different centres.

(Harris, 1985, p.917). A female to male ratio of 2:1 to 3:1 was reported (Harris, 1985, p.917). An increase in rheumatoid arthritis (RA) in South African blacks was reported, with a difference of 33/1000 in urban blacks compared to 8,7/1000 for rural blacks (Harris, 1985, p.197). In a study done at the Groote Schuur Hospital Rheumatology Unit, it was however found that the prevalence of patients referred to the clinic was proportional to the distribution of different race groups in the Cape Peninsula, as obtained from the 1985 census (Mody and Meyers, 1989) The discrepancies in prevalence statistics from different centres in the world could probably just as well arise from biased sampling as from real differences. Studies on RA tend to be retrospective and are usually on samples taken from hospital populations which may differ systematically from the general population.

Mody and Meyers (1989) did however report a milder disease pattern in black patients, and so did Chopra et al (1988) for patients in India, compared to other racial groups. This leaves us with the question: Is the fact that different race groups suffer from different types of RA genetically determined, or are the differences due to difference in life style?

The HLA-DR4 genetic factor is shown to be twice as frequent in RA patients testing positive for rheumatoid factor as in the general population. A genetic predisposition is therefore hypothesised (Van der Heijde et al, 1988). The difference in prevalence of RA between urban and rural blacks could however only be ascribed to environmental factors including life style.

In an American national health survey a higher prevalence of RA was found amongst people who had been educated for five years or less and who were in the lower income groups (Harris, 1985, p.918). It is possible that low income, accompanied by malnutrition, influenced the RA trigger, or low income could be coincidental with little education and completely unrelated to the prevalence of RA. On the other hand contraction of the disease might have led to a lower income, but it does not explain lack of education. Income and education are not mentioned elsewhere as being prognostic factors for RA, apparantly because of a lack of research done in the field.

Socioeconomic status as a broader term, which includes factors like literacy, income and aspects of lifestyle such as diet and activity, however seems to be a factor well worth considering when a prognosis of RA is predicted.

1.2 NATURAL COURSE:

The natural course of the disease has been described by different patterns of onset, different patterns of cyclic behaviour as well as rapid or slow progression.

Harris (1985, p.919-921) discriminated between three distinct patterns of onset:

(1) In an insidious onset the symptoms can develop slowly over weeks or months, usually starting with morning stiffness and leading to slight atrophy of muscles. About 55% to 70% of patients experience this.

(2) A small number of patients (8%- 15%) suffer from an acute attack of RA following some incident such as influenza, the birth of a baby, the loss of a spouse and various other "triggers".

(3) The intermediate onset is something between the insidious and acute types, with symptoms developing over days or weeks and is accompanied by systemic complaints. From 15% to 20% of sufferers experience this.

Flatt (1983, p.8) distinguished three courses the disease could take:

(1) The monocyclic variety of patient suffers from R A for two or more years. The illness goes into remission and the patient is symptom free. About 35% of patients are this fortunate.

(2) The majority of patients (approximately 50%) suffer from a polycyclic disease. This form is recognised by the appearance and disappearance of symptoms which leave the patient more disabled after each "flare up".

(3) The progressive type never abates. The symptoms just get worse in time. This is the fate of around 15% of patients. Harris (1985, p.921) distinguished between rapid and slow progression as well.

Harris (1985, p.921) reported that 20% to 30% of patients undergo partial or complete remissions, which is a low figure compared to Flatt's percentages. These remissions often (50% of times) lasted more than a year and up to 10% of patients had remissions lasting for 22 years (Harris, 1985, p.921).

In 90% of patients who turn out to have erosive disease of the joints, these erosions occurred within the first two years of onset (Van der Heijde et al, 1988).

It becomes clear that the varieties of disease patterns are numerous. A patient may suffer an acute attack which progresses rapidly but is monocyclic. On the other hand, the disease may have an insidious onset, be polycyclic and progress slowly. How these factors combine or fail to combine makes a subclassification of the spectrum of the RA disease possible, although this has not yet been established.

1.3 PROGNOSIS:

Prognosis can be described on different levels, including death, disease and disability.

Patients with severe RA have a life expectancy of 10 to 15 years less than the normal population (Rasker and Cosh, 1989).

Although a patient with a rapid onset of disease has a better prognosis in the intermediate time, no difference in disease severity can be established after seven years (Harris, 1985, p.943).

A positive Rheumatoid Factor in the blood and subcutaneous nodules are elements frequently associated with a poorer prognosis. (Harris, 1985, p.943)

Females have worse prognoses than males (Harris, 1985, p.943)

Patients on long term corticosteroids are more prone to subluxations of the cervical spine and more gross deformities in the hands may be expected (Rasker and Cosh, 1989).

Dieppe et al (1985, p.64) outlined the prognosis for development of disability as follows: 24% sufferers remain fit for all normal activities, 40% have moderate impairment, 26% are badly disabled and 10% are wheelchair bound. Whether this prognosis is valid for all settings with different treatment preferences, facilities, staff patient ratios and staff expertise is not clear.

1.4 EFFECT OF RA ON JOINTS AND ADJACENT STRUCTURES:

RA presents itself in the sufferer as an inflammatory process in the highly vascular connective tissue in the synovium. The thickened synovial tissue spreads over the articular joint surfaces as a pannus and fills the synovial cavity. The proximal interphalangeal (PIP) joint usually presents clinically as a fusiform palpable swelling (Renner and Weinstein, 1988). Synovial swelling causes stretching of the joint capsule and ligaments and when swelling eventually abates, the joint is left with a slack capsule and ligaments (Helal, 1984).

The thickened synovial layer of cells causes erosion of the adjacent peripheral cartilage laying bare subchondral bone (Burke, 1984). Eventually the synovium invades bone to produce erosions. Flatt (1983) describes a clinical process whereby bone erosions are picked up on X-ray films before deformity becomes evident (Flatt, 1983, p.11). It can be hypothesised that although joint laxity is the result of swelling occurring before erosions take place, joint laxity is prevented by a healing process in the early stages. After constant stretching and subsiding, the soft tissue around the joint becomes less resilient and the healing process ineffective. This may explain the onset of deformities at a later stage than evidence of erosions.

Not only do joint surfaces, ligaments and bones become affected, but the inflammatory process can proceed to muscle fibres causing wasting (Burke, 1984). The small muscles in the hand lying in close proximity to joints and synovial tissue are especially vulnerable. Interosseus and lumbrical atrophy can be seen in the hand at an early stage. One of the causes of the swan neck deformity, intrinsic tightness, can probably be a secondary effect of this process (Burke, 1984).

Tendon synovitis is a common occurrence in the RA hand. The thickening of the synovial lining of the flexor tendon sheaths causes mechanical obstruction to the sliding of tendons in their sheaths. Furthermore the constant pressure on the tendon by the swelling may damage and ultimately rupture the tendon. The extensor tendons passing under the retinaculum are especially vulnerable (Burke, 1984).

Nerve lesions such as the carpal tunnel syndrome, trapping the median nerve by thickened synovial tissue at the wrist and ulnar nerve entrapment at the wrist or the elbow, are not infrequent. In the RA patient the sensory dysfunction is less clearly delineated in the dermatomes. A glove-like anaesthesia following nerve involvement is indicative of a more diffuse infiltration of nerves than would be expected in an ordinary neuropraxia (Burke, 1984).

The skin of the RA hand is often thin and upon pressure on a digit, capillaries are slow to refill. Profuse synovial swelling does not leave enough space for normal circulation and vasculitis is a common complication in RA (Burke, 1984).

Joint involvement in RA is usually symmetric. One of the criteria for diagnosis set by the American Rheumatoid Association is symmetric involvement of joints (Harris, 1985, p.919). Nevertheless it is often postulated that the dominant hand is more affected than the left hand (see 3.3).

It is mostly the metacarpo-phalangeal joints (MP), the PIP joints and the wrists that are involved. In 45% of patients the first joint that becomes inflamed is the PIP joint (Harris, 1985, p.920).

If it is true that most of the pain and damage in and around the joint has some connection to increased pressure, is it possible that the external atmospheric pressure could also have an influence? Guedj and Weinberger (1990) reported that the weather changes that cause an increase in the pain of RA patients are related to barometric pressure rather than temperature. These results were however inconclusive due to a small study sample.

2. DEFORMITIES OF THE RA HAND:

2.1 SWAN NECK DEFORMITIES:

Causes of the swan neck deformity described by various authors are diverse, but can all be explained by tracking down the primary target of synovial invasion in the finely balanced musculo-skeletal system. It is clear that the diversity of types of swan neck deformity is due to the fact that any of the elements of this closed system could be the first domino to topple and cause the self-destructing cycle which results in a fixed swan neck deformity. It is important to note that swan neck deformities are not

only found in RA, but many other disorders, such as Parkinson's disease, cerebral palsy, burns and various hand injuries (Pretorius, 1988, p.29).

Philips (1989) sums up the causes of swan neck deformity in RA as being (i) intrinsic muscle tightness; (ii) stretched volar plate; (iii) mallet deformity; (iv) ruptured flexor digitorum superficialis (FDS) tendon.

INTRINSIC TIGHTNESS:

Flatt (1983, p.130) states that the primary cause of swan neck deformity is intrinsic tightness. The inflamed MP capsule emits pain stimuli when stretched in extension. A protective flexion deformity in the interosseus muscle ensues. The muscles are held in flexion and are therefore subject to secondary fibrosis in this shortened length (Flatt, 1983, p. 93). Shortening of the intrinsic muscles upsets the longitudinal arches of the hand and results in an increased pull on the central slip of the extensor expansion to the digit (see Fig. 1) due to relative skeletal lengthening. The excessive traction on the extensor apparatus causes dorsal displacement of the lateral bands, which now have a shorter excursion to the DIP joint. The flexor digitorum profundus (FDP) tendon is under increased tension when it endeavours to help flex the PIP joint and the subsequent DIP flexion is unopposed by the lateral bands (Tubiana and Toth, 1984). The net result is a swan neck deformity with PIP hyperextension and DIP flexion as well as the added problem of intrinsic tightness.

FIG 1: SWAN NECK DEFORMITY

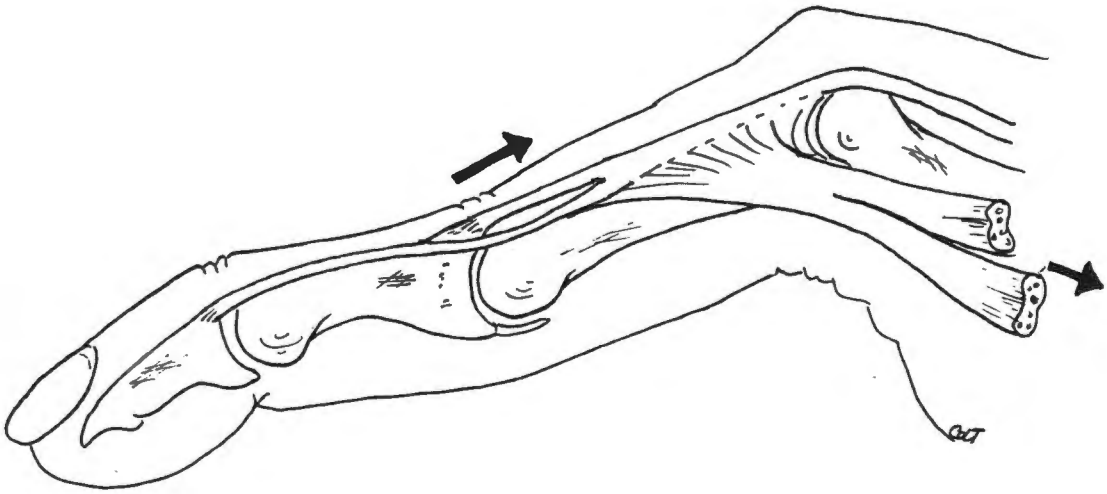


Fig 1: Overaction of the intrinsic muscles increases the tension on the middle slip

A test for intrinsic tightness suggested by Bunnell is quoted by several authors (Welsh and Hastings, 1977; Flatt, 1983; Harris, 1985; Pretorius, 1988). The test is done in two stages. In the first stage, passive flexion to all three digital joints is performed to exclude extrinsic extensor tendon involvement. If passive motion is full, proceed to the second stage: tense the intrinsic muscles by holding the MP joint in full extension and then apply dorsal pressure on the distal phalanx. If intrinsic tightness is present, the degree of resistance to passive flexion gives an indication of the degree of intrinsic tightness.

STRETCHED MP VOLAR PLATE:

Primary involvement of the MP joint results in disruption of the volar plate (see Fig. 2). This causes a volarly subluxed MP joint. The extensor digitorum muscle (ED) is now ineffective in extending the proximal phalanx, and puts excessive traction on the central slip of the extensor expansion. The interosseus muscles are allowed to rest in a shortened position, causing intrinsic tightness (Evans, 1984).

FIG.2: SWAN NECK BY MP VOLAR PLATE DISRUPTION

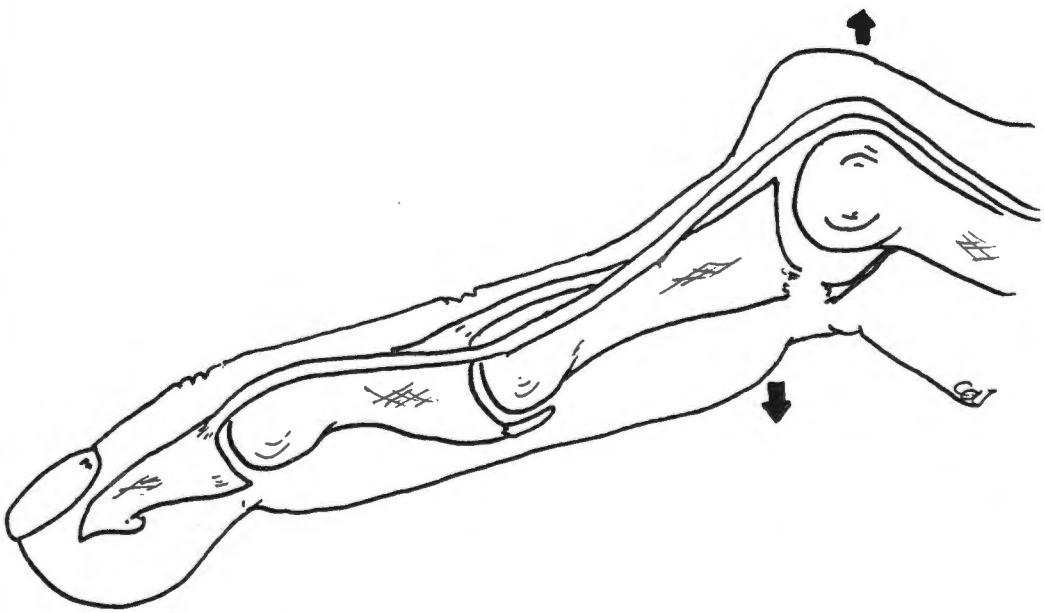


FIG. 2: MP volar plate disruption with subluxed MP joint putting tension on the middle slip of the extensor expansion.

Tubiana and Toth (1984) as well as Evans (1984) play down the role of primary intrinsic tightness, but postulate it to be a result rather than a cause of swan neck. Which was first, the chicken or the egg?

The so called "snapping swan neck" deformity (see Figs. 3A and 3B) can be demonstrated in a normal hand with lax digital joints, but can also be an indication of a PIP joint which became lax because of synovial swelling. In an attempt to flex the PIP joint from hyperextension, the DIP joint is pulled into flexion by the FDP, resulting in increased tension in the lateral bands of the extensor expansion. The lateral bands are bowstrung over the PIP joint and pulled proximally by the lumbrical muscles arising from the contracting FDP muscle. When the resultant force of the FDP overcomes the passive forces keeping the PIP joint in extension, the lateral bands are "snapped" volarly and PIP flexion becomes possible (Evans, 1984).

FIG 3: SNAPPING SWAN NECK DEFORMITY

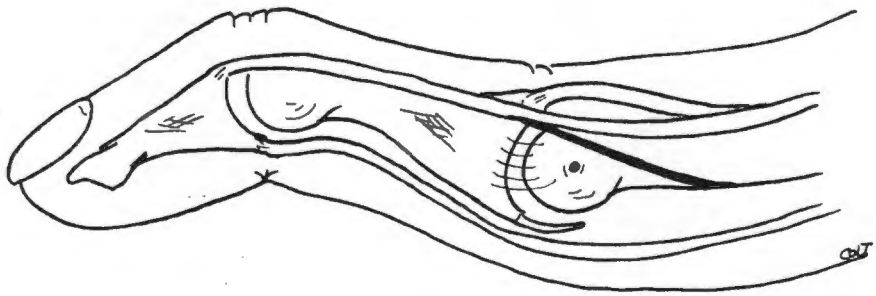


Fig 3A: The attempt to flex the finger results in DIP flexion.

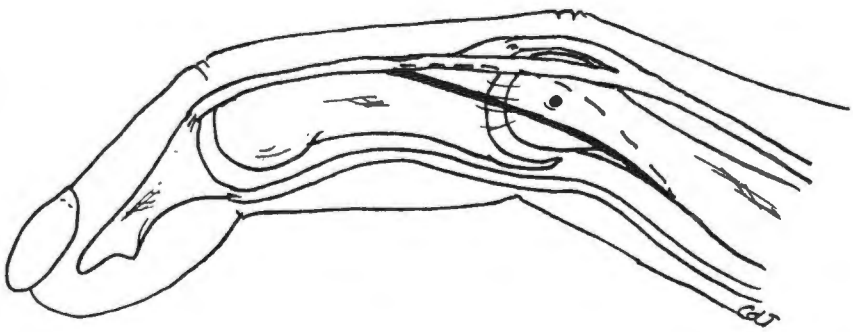


Fig 3B: Continuous flexion overcomes the resistance of the lateral bands which are "snapped" volarly as the PIP joint flexes.

MALLET DEFORMITY:

A mallet deformity is caused by interruption of the continuity of the terminal extensor of the finger, resulting in unopposed flexion of the DIP joint by the FDP muscle (Zancolli, 1979, p.93). In RA, synovitis of the DIP joint causes stretching or ultimate rupture of the extensor tendon in this area. The retinacular ligament (see Fig 4), running from the volar middle phalanx to its insertion on the dorsum in the distal end of the digital extensor, migrates proximally, the lateral bands of the extensor are relaxed and the full force is placed on the middle slip, with the resulting swan neck deformity (Zancolli, 1979, p.93).

FIG 4: MALLET FINGER

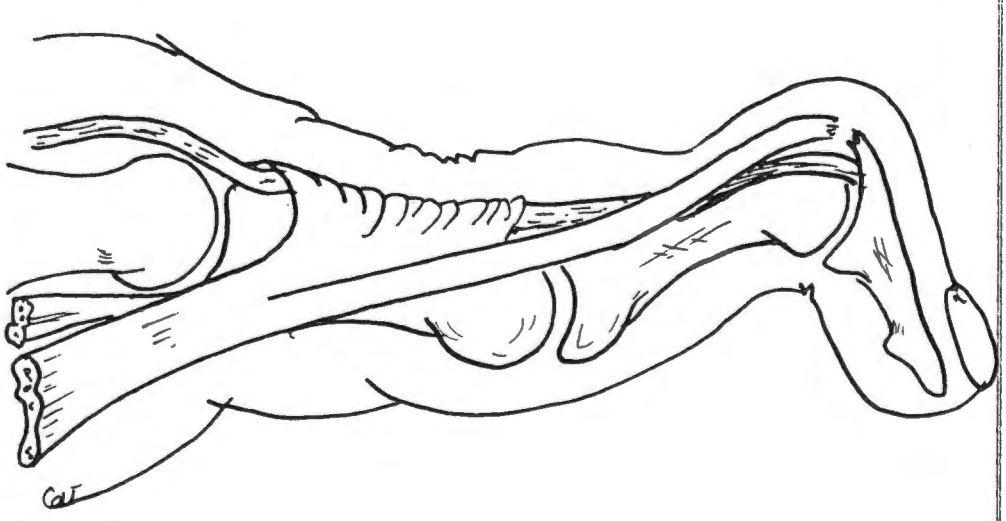


Fig 4: Mallet finger caused by disruption of the terminal extensor attachment.

However, as discussed earlier, primary DIP involvement is not as prevalent, and mallet finger as a cause of swan neck deformity should not be overrated.

RUPTURED FLEXOR DIGITORUM SUPERFICIALIS:

Damage to the FDS tendon by synovial swelling and entrapment in the flexor sheaths together with the subsequent obliteration of blood supply to the tendon, may cause rupture of the tendon (Flatt, 1983, p. 101). The PIP joint has lost its main flexor and is unable to flex other than by FDP. The strong action of the central slip of ED is thus not countered by a large enough force. This imbalance results in a swan neck deformity (see Fig 5). A "snapping swan neck" deformity described above is also seen with a rupture of FDS.

FIG 5: DISRUPTION OF FDS TENDON

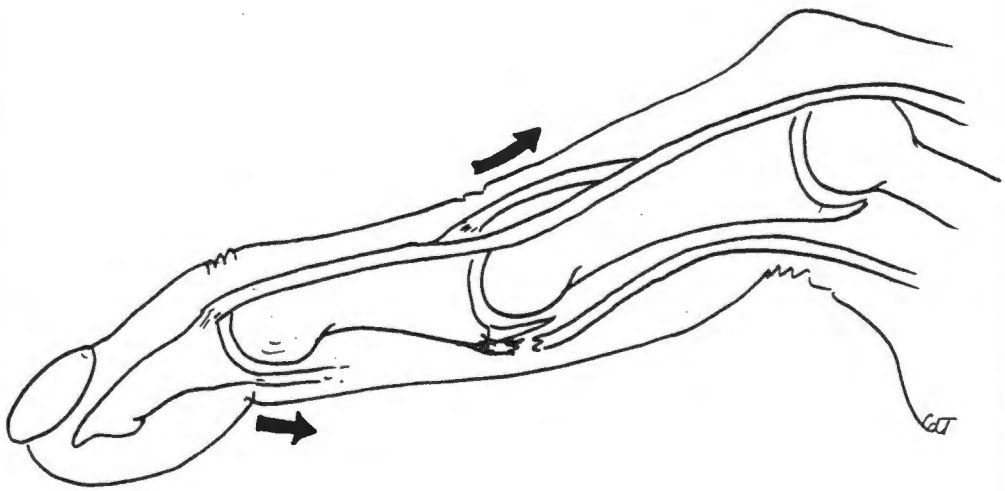


Fig 5: Damage to the FDS tendon with accompanying PIP volar plate laxity poses no opposition to the middle slip of extensor digitorum.

It must become evident that any of the "players" in the development of a swan neck deformity may begin the process, which causes any one or more of the others to join in, and by the time the patient is seen, it is often impossible to tell where it all started. Sometimes it is possible to guess which factor is playing the major role at the moment, but as Imbriglia (1987, p.121) concurs, the next focal force of the developing deformity is as yet totally unpredictable. The clinician needs a means to evaluate the deformity at its present state and to discriminate between deformities where the primary force is the only one present, where more than one factor is present or when a fully fledged deformity exists.

Nalebuff and Millender (1975a) distinguished between four types of swan neck deformity:

TYPE 1: PIP joints are flexible in all positions:
The deformity can start at the PIP or DIP joint.

TYPE 2: PIP joint flexion is limited in certain positions:
Intrinsic tightness is evident.

TYPE 3: Limited PIP joint flexion in all positions:
This indicates secondary soft tissue changes.

TYPE 4: Stiff PIP joints with poor X-ray appearance.

This classification of deformity, however useful in distinguishing between the different forces, does not indicate a sequential development of the deformity. Type 2 deformity, characterised by intrinsic tightness, may in the case of primary intrinsic tightness be only the first signs of the deformity, where in other cases it could be an indication of secondary soft tissue changes. The distinction between type 3 and 4 would only be apparent when X-ray films were available in the clinical situation. It is therefore not feasible to try to discriminate between types 3 and 4 deformities at monthly follow-up visits, because of the cost involved.

Welsh and Hastings (1977) used a system for grading swan neck deformities distinguishing only between mobile swan neck with or without intrinsic tightness; snapping swan neck and fixed swan neck. As indicated above, the snapping swan neck can be demonstrated in normal hands (Flatt, 1983)

with lax joints, and cannot be described as a worsening of swan neck deformity. Different grades of development of swan neck deformity are therefore presented in Table 1, taking these factors into consideration.

TABLE 1: GRADING OF SWAN NECK DEFORMITIES:

GRADE I	No restriction on passive range of movement (ROM) of metacarpophalangeal (MP) or proximal interphalangeal (PIP) joints. Slight hyperextention of PIP joints or lack of normal flexion position at rest.
GRADE II	The above coupled with flexion of the distal interphalangeal (DIP) joints plus any of the following signs: Intrinsic tightness; Snapping of lateral bands volarly; evidence of soft tissue involvement.
GRADE III	PIP joints are stiff in extension. Passive movement is difficult to achieve.

2.2 BOUTONNIERE DEFORMITIES:

Authors generally agree that the boutonniere deformity develops due to injury of the extensor expansion (Souter, 1974; Nalebuff and Milender, 1975b; Evans, 1984; Tubiana, 1984; Pretorius 1988, p.30). This damage upsets the balance that normally exists between the extensor complex and the FDS and FDP muscles. Laxity of the middle slip causes the PIP to assume a flexed position with resulting increase in tension on the lateral bands which slip volarwards (See Fig. 6).

FIG 6: BOUTONNIERE DEFORMITY

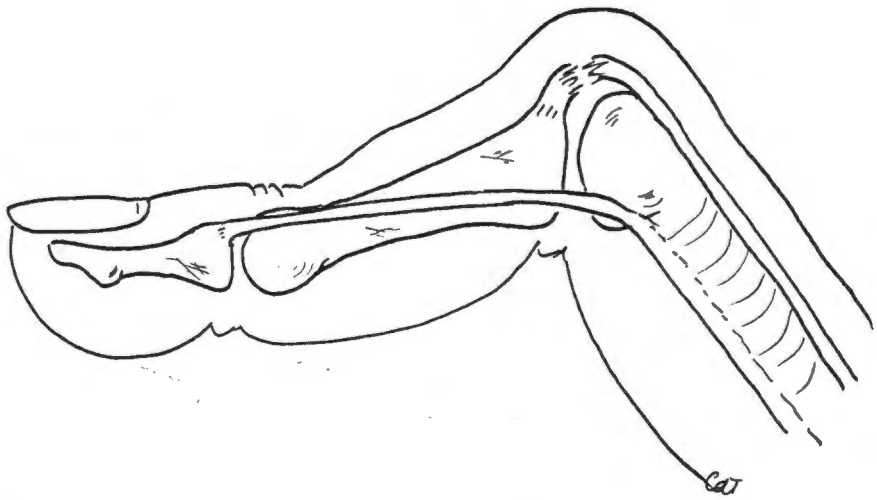


Fig 6A: The middle slip of the extensor mechanism is injured and the lateral bands slip volarly.

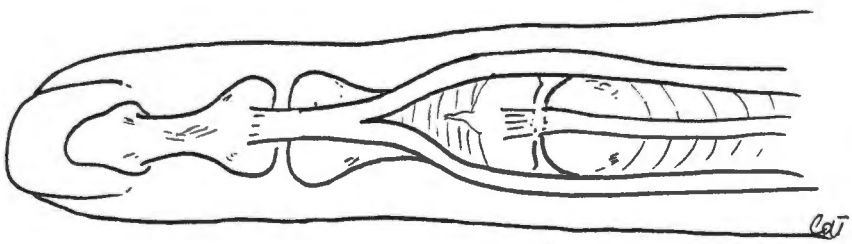


Fig 6B: Dorsal view of the disrupted middle slip.

Over action of intrinsics on the lateral bands causes hyperextension of the DIP. If this position is maintained, the transverse retinacular ligaments

contract (See Fig. 7), and a fixed boutonniere deformity may be the result (Souter, 1974).

FIG 7: BOUTONNIERE DEFORMITY

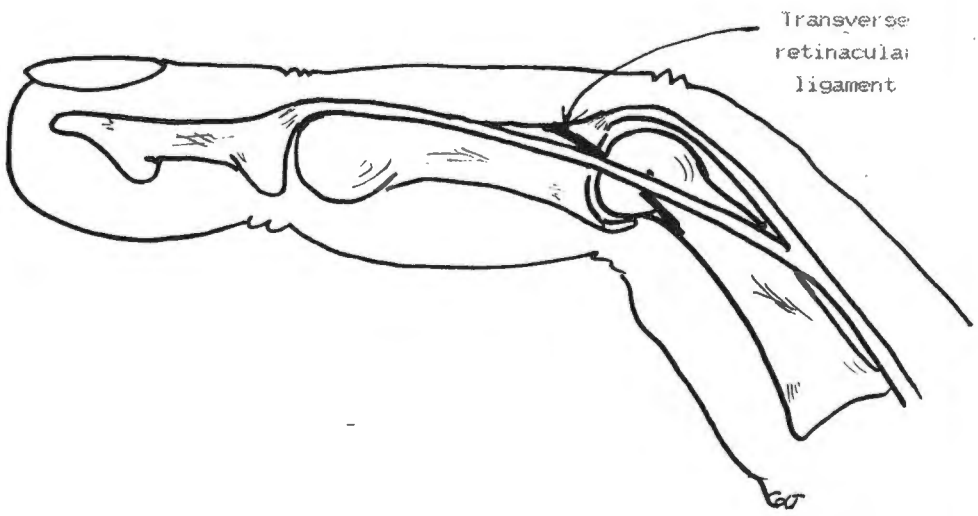


Fig 7: Shortening of the transverse retinacular ligament aggravating the boutonniere deformity

In RA, invasive synovitis causes destruction of ligaments, the joint capsule and tendons. The prime site of slow destruction of tendon tissue is the PIP joint (Flatt, 1983, p.102). Once the lateral fibres of the extensor expansion get separated from the central slip, the boutonniere deformity becomes evident (Imbriglia, 1987, p.121). Tubiana (1984) is adamant that rupture of the middle slip of the extensor expansion does not lead to deformity if the lateral bands' attachments to the dorsum of the distal phalanx are intact.

Nalebuff and Millender (1975b), Flatt (1983, p.144) and Pretorius (1988, p.30) describe three definite stages in development of the boutonniere deformity:

In STAGE 1 (mild deformity) the patient has only a slight lag of PIP extension (10 to 15 degrees). On examination passive extension is full. With PIP flexion the DIP joint is in a normal flexed position.

In a STAGE 2 deformity (moderate) the extensor mechanism over the PIP joint becomes more attenuated and the lateral bands are displaced volarly. The joint is now in 50 degrees flexion and the DIP hyperextension is pronounced. DIP extension does not correct with PIP flexion, but can still be passively flexed with correction of the PIP joint. Pretorius (1988, p.31) described the retinacular test as being positive when while holding the PIP joint passively in extension the DIP joint can be passively flexed. If however the DIP resists passive flexion, it is indicative of shortening of the retinacular ligaments and the retinacular test is negative.

STAGE 3 (severe) deformity is fixed and resistant to passive movement. The end stage consists of extended MP, flexed PIP and extended DIP joints.

Grading of the extent of the boutonniere deformity is presented in Table 2.

TABLE 2: GRADING OF BOUTONNIERE DEFORMITIES:

GRADE I	Mobile PIP joint, but assuming flexion position if asked to stretch hand. Retinacular test positive.
GRADE II	PIP joint still fairly mobile with some extensor lag. Retinacular test negative. Soft tissue involvement evident.
GRADE III	PIP joints stiff in flexion. Passive extension very difficult.

2.3 OTHER ASSOCIATED DEFORMITIES:

WRIST involvement occurs in 75% of sufferers (Tubiana, 1984). The extensor carpi ulnaris (ECU) synovial sheath at the distal radioulnar joint gets inflamed. Weakening of the triangular ligament between the radius and ulna results in subluxation of the ulnar head. The ECU is displaced volarly and ulnar deviation at the wrist is lost. The wrist assumes a radially deviated position, causing non alignment of the long digital extensor tendons. This could be one of the causes of ulnar deviation at the MP joints (Evans, 1984, Harris, 1985, p.376).

ULNAR DEVIATION AT THE MP JOINTS is one of the common deformities of RA and different theories exist of the cause for it. Tubiana (1984) attribute this deformity to

(i) the asymmetry of the metacarpal head

(ii) more intrinsic muscles on the ulnar side

(iii) the thumbs action against the radial side of the second finger.

(iv) ECU malalignment as discussed above.

Harris (1985, p.931) added another two possibilities:

(v) in power grasp the fingers are pulled ulnarwards especially if appropriate intrinsic action is lacking,

(vi) laxity of capsule and ligaments of the MP joints together with any ulnar force (see i to v) causes the joints to assume an ulnarly deviated stance.

As postulated with the swan neck deformity, ulnar deviation could in one patient be caused by one factor, whilst in another patient a totally different problem or possibly a combination of factors could cause the deformity.

Synovial involvement within the flexor tendon sheath could cause entrapment and ultimate rupture of tendons. This is often felt in the palm of the hand as a nodule blocking movement (Evans, 1984). These deformities could well influence the development of swan neck and boutonnière deformities because of their effect on the muscular balance in the hand.

3. DEVELOPMENT OF DEFORMITY IN TIME:

3.1 NATURAL COURSE OF DEVELOPMENT:

In a follow-up study of 11,9 years Sherrer et al (1986) reported that deterioration of RA occurs most rapidly in the first five years after onset of the disease. Meenan et al (1988) in a five-year study stated that the health status of patients with established disease is "more stable than previously thought", whatever was previously thought. Of 23 patients followed for two years by Feinberg and Brandt (1984), three acquired ulnar deviation; three MP subluxation; five developed swan neck; 11 experienced loss of active PIP extension and one lost both active and passive PIP extension. Wood et al (1989) obtained similar results in that in a three-year period two out of twelve patients suffered worsening of swan neck deformities.

The factors to keep in mind when studying development of swan neck and boutonniere deformities in RA patients are therefore firstly to allow some time for the deformities to develop - two years in the case of Feinberg and Brandt (1984) was enough. Secondly it should be kept in mind how early or late after onset of the illness the patient is included in a study.

3.2 THE INFLUENCE OF ACTIVITY ON DEFORMITY:

The development of deformities could also be influenced by other factors. Helal (1984) distinguished between intrinsic and extrinsic forces. Intrinsic forces are those of muscle imbalance described in the earlier paragraphs and extrinsic forces include gravity and forces produced by the pattern of use of the hand. The widely published and universally used "joint protection principles for RA" (Davis and Janecki, 1978; Flatt, 1983, p.39; Chamberlain et al ,1984; Pedretti and Kasch, 1985, p.298; Agnew, 1987; Philips 1989) is based on the assumption that if the extrinsic forces on the vulnerable joints are controlled during activity, the joints should experience less damage and subsequently less deformity should develop. The joint protection principles as treatment modality of occupational therapists has however never been substantiated by research. This oversight was mentioned by Chamberlain et al (1984) and discussed in a literature study by Agnew (1987).

3.3 INFLUENCE OF HAND DOMINANCE ON DEFORMITY:

If activity has an adverse effect on the integrity of joints, one should be able to pick up a difference in development of deformities in the dominant compared to the non-dominant hand. One of the criteria for diagnoses of RA is the symmetry of the involvement in left and right hands (Harris,

1985, p.919), which implies that the dominant and non-dominant hands are involved more or less equally.

A few studies were attempted to indicate that the dominant hand is deformed more often than the non-dominant hand. Mody et al (1989) studied 248 swan neck and 123 boutonniere deformities at Groote Schuur Hospital, but found no significant differences in prevalence of deformity in the dominant and non-dominant hand. Kemble (1977) found that the MP ulnar deviation of the dominant hands had larger angles than the non dominant hands. It is therefore possible that dominant and non-dominant hands differ in terms of severity rather than prevalence of deformity. This will tie in with the findings of Renner and Weinstein (1988), Kemble (1977) and Mody et al (1989) that the difference in the dominant and non-dominant hands detected was in terms of radiological findings of joint space narrowing and erosions only.

4. SUGGESTED PREVENTATIVE TREATMENT FOR DEFORMITIES:

Philips (1989) stresses the importance of prevention of the disabling effects of RA in the early stages of the disease. This is in accordance with the Sherrer et al (1986) study stating that the most rapid deterioration occurs in the first five (5) years after onset.

4.1 JOINT PROTECTION:

Joint protection principles outlined by Flatt (1983, p. 39) may be summarised as follows:

1. Respect pain.

Any pain indicates the presence of a potentially deforming extrinsic force.

2. Achieve a balance between rest and work.

Any activity continued for any length of time might render an already weakened muscle too exhausted to assist ligaments and joint capsules that are also eroded by an inflammatory process in maintaining joint integrity. The extra strain on the joint, may cause further damage to the soft tissue around the joint.

3. Maintain muscle strength and joint range of motion.

As seen in 2 above a strong muscle can protect a joint and added to that, if the maximum joint range is preserved, muscles can work at their optimum efficiency (Lehmkuhl and Smith, 1983, p.133).

4. Reduce the effort needed to do a job.

Reduction of the force that is needed to perform the activity leads to reduction of extrinsic forces on the joints.

5. Avoid the positions of the deformity.

Avoidance of positions of deformity allows the joint to escape temporarily from the extrinsic forces that may possibly aggravate commonly found deformities and permits the soft tissue to recover.

6. Use the strongest or largest joints available for the job.

Using the larger instead of the smaller joints for activity assures that the hands are used less in favour of elbows and shoulders where stronger muscles are available to protect joints against excessive strain.

7. Use each joint in its most stable anatomical and functional plane.

Using each joint in its most stable anatomical position avoids stretching of diseased ligaments and tendons in directions which are only possible because of laxity of ligaments and thus harmful. Furthermore, the position of optimum muscle work is achieved (see no. 3).

8. Avoid holding or staying in one position for prolonged periods of time.

Isometric muscle work is more tiring than isotonic work (Grandjean, 1986,p.11). Muscles having to contract for prolonged periods cannot adequately protect ligaments and joint capsules.

9. Avoid activities that cannot be stopped immediately if they become too stressful.

If an activity cannot be stopped when pain is experienced, the same effect as in 8 ensues.

10. Use of assistive equipment and splinting to protect joints.

Using assistive equipment is a way of reducing the effort needed for a job or avoiding the position of deformity (see 4 and 5). Splints used in activity take over the role of stabilising muscles which have to contract isometrically for long periods (see no. 8).

4.2 EXERCISE:

The benefits of exercise for the arthritic patient include maintainence of joint range, a feeling of well-being and the provision of muscle power to act as a 'shock absorber' for the affected joints during movement (Gerber and Hicks, 1990, p. 333). Active exercises are preferred for RA patients above passive movement of joints by a therapist. Isometric exercise is only advocated when the joints are quiescent so as not to cause joint effusion and further destruction (Agudelo et al , 1972).

Brooke et al (1972) demonstrated that muscle atrophy of different types of muscle fibres occurs at different stages of development of RA. In the early stages it is mainly the type 2b fibres which are responsible for voluntary forceful and rapid movement that are affected, mainly because of intentional disuse because of pain. In severe RA type 1 muscle fibres responsible for the more reflex-controlled movements are mainly affected. Brooke et al (1972) also found that a number of severely affected RA patients had marked type 1 fibre atrophy but no type 2b fibre atrophy. They attributed this to voluntary "reflex splinting" of the painful joint by type 2 muscle fibres. This could be explained thus: the patient keeps his muscles continuously contracted to protect the painful joint. These muscles do not loose power as they would have if the muscles were relaxed. Why

this phenomenon is only evident in some cases is probably due to personal differences among patients.

Considering this variation in atrophy patterns linked to the diverse functions of muscles in the hand, it is probably shortsighted to limit exercises for prevention of muscle atrophy to light active isotonic movement, excluding the other types of muscle work.

4.3 SURGERY FOR DEFORMITY:

Synovectomy for the PIP joints of RA patients is an established procedure to relieve pain and to halt the destructive process preventing boutonniere deformities (Imbriglia, 1987, p.123). If biomechanical factors have already influenced joint integrity, the synovectomy is usually combined with one or more of the techniques discussed below (Welsh and Hastings, 1977).

For a mobile swan neck deformity with normal intrinsic muscles Welsh and Hastings (1977) prescribe a synovectomy plus flexor digitorum superficialis tenodesis and for a snapping swan neck the lateral bands are in addition anchored volarly. Besser (1978) manipulates the swan neck which is limited in all positions (grade 2) under anaesthesia, positions the PIP joint in 70 to 90 degrees flexion with Kirschner wires and maintains this for three weeks. If the deformity tends to recur, flexion is sustained by elastic bands for three weeks. Nalebuff and Millender (1975a) suggested a dermadesis of the volar aspect of the PIP joint for a Grade 1 swan neck.

The net result of the above procedures is shortening of the flexor tendon and skin, preventing dorsal displacement of lateral bands. Providing a splint to position the PIP joint in flexion should potentially have the same effect if the diseased soft tissues can shorten sufficiently by themselves.

When a flexion deformity at the DIP joint is the primary problem, a DIP fusion is suggested by Nalebuff and Millender (1975a). For swan neck deformities with intrinsic tightness an intrinsic release is recommended by Nalebuff and Millender (1975a) and Flatt (1983, p.131).

Suggested surgical treatment of a grade I boutonniere deformity (see Chapter II, 2.2), is an extensor tenotomy over the middle phalanx (Nalebuff and Millender, 1975b and Imbriglia, 1987, p.126). Flatt (1983, p.145) stresses the importance of using a dynamic splint in addition to this procedure.

In RA patients with a grade II boutonniere deformity, repair of the defect in the extensor mechanism is not easy (Nalebuff and Millender, 1975b). This includes repair of extensor digitorum communis and restoration of the balance of the lateral bands in relation to the central slip to ensure that the lateral bands are above the axis of the joint (Flatt, 1983, p. 145).

For a stage three deformity, a fusion of the PIP joint in a functional position is recommended (Nalebuff and Milender, 1975b, Flatt, 1983, p.148).

The rationale for surgical treatment for grades I and II deformities is to allow the stretched or ruptured middle slip of the extensor mechanism to heal in a shortened position, while positioning the lateral bands dorsal to the PIP axis of movement.

5. SPLINTING FOR DEFORMITY:

Davis and Janecki (1978) state that splints to delay or correct deformity could be "helpful". Pedretti (1985, p. 258) lists "prevention of deformity" as one of the purposes of splints. The writers have however not provided an answer as to which splint is recommended at what stage for which

deformity, and none of the authors refer to research to support their recommendations.

5.1 SPLINT DESIGNS FOR SWAN NECK DEFORMITY:

The splint most commonly recommended for swan neck deformity (see fig. 8) is called by different names: the 'donut' by Flatt (1983, p.50); the 'figure of eight' by Carter (1987, p.237); 'three point splint for swan neck' by Malick and Kasch (1984, p. 132); 'anti swan neck' by Merrit (1987); "PIP hyperextension splint' by Philips (1989) and 'finger splint to prevent hyperextension' by Davis and Janecki (1978). For the purpose of this study, the name 'PIP hyperextension splint' will be adopted, being descriptive and not to be confused with the dynamic figure of eight splint or any other 'swan neck splint'.

FIG.8: PIP HYPEREXTENSION SPLINT

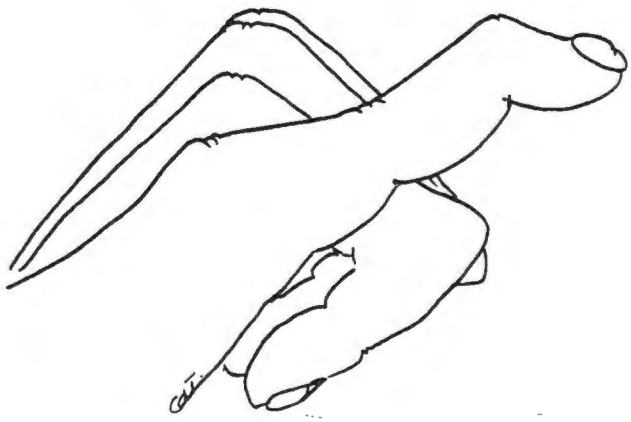


Fig 8a: PIP hyperextension

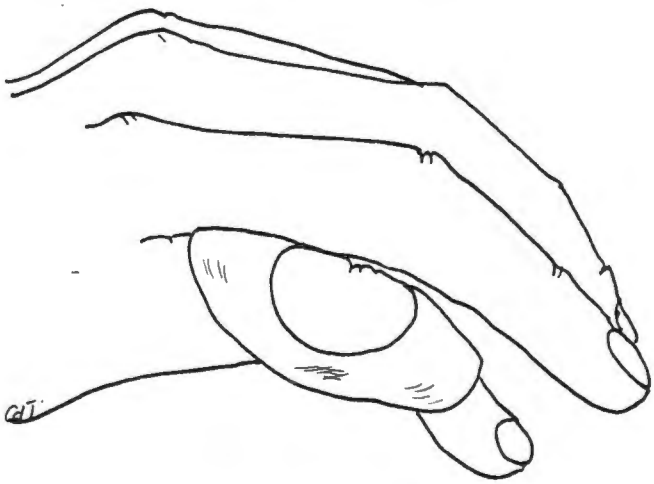


Fig 8b: Splint prevents hyperextension of the PIP joint.

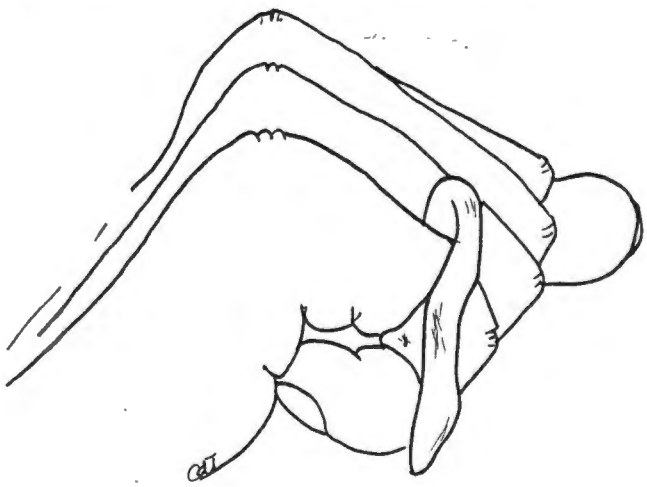


Fig 8c: Splint allows full PIP flexion.

The splint allows full flexion of the PIP joint, but restricts extension to as much as the therapist who is making and fitting it permits. Although it is in essence a static splint, it has a dynamic aspect in allowing active flexion, but differs from other dynamic splints in that no passive force is placed on the joint structures. None of the authors who advocate splinting name how many degrees short of 180 degrees extension, the splint should permit. Carter (1987, p.238) describes a dorsal aluminium splint keeping the PIP joint passively in 10 to 20 degrees flexion after PIP joint arthoplasty. For the "PIP hyperextension splint" it would seem logical to place the PIP joint in enough flexion to allow the dorsally displaced lateral bands to slip back volarwards to the joint axis, but not so much as to leave an nonfunctional hand if the PIP joint becomes stiff in that flexed position. In practice this would coincide with 10 to 20 degrees of flexion.

Ellis (1984) advocates dynamic figure-of-eight splints (Fig. 9) for PIP joints that have inadequate flexion. This splint (in the writers opinion erroneously named "reversed finger knuckle bender) is also advocated by Trombly (1989, p. 337) for contractures of the PIP joint.

FIG 9: DYNAMIC FIGURE-OF-EIGHT SPLINT

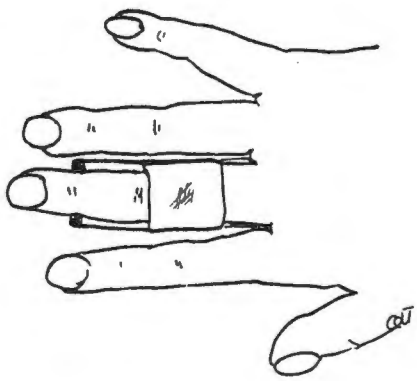


Fig 9a: Splint from dorsal view

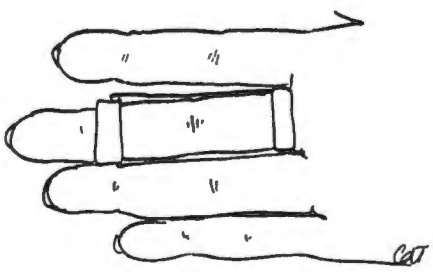


Fig 9b: Splint from volar view

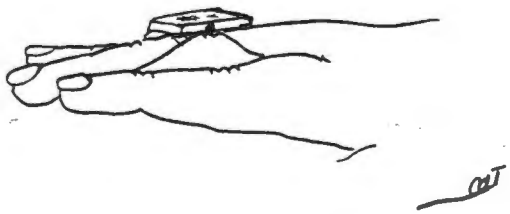


Fig 9c: Splint from side view. Note placement of dorsal pad proximal to PIP joint

The splint dynamically forces the PIP joint into extension and the patient is asked to flex actively against the spring wire of the splint in order to increase the flexion range of motion. The author does not state that this splint is indicated for swan neck deformities, but she recommends it for stiff PIP joints of RA patients. The reverse figure of eight splint applies three point pressure on the reverse side of the finger as was done by Ellis' splint (see Fig.10). It would seem more logical to use this splint to dynamically push the PIP joint into flexion and gain flexion range passively.

FIG. 10: DYNAMIC REVERSE FIGURE-OF-EIGHT SPLINT

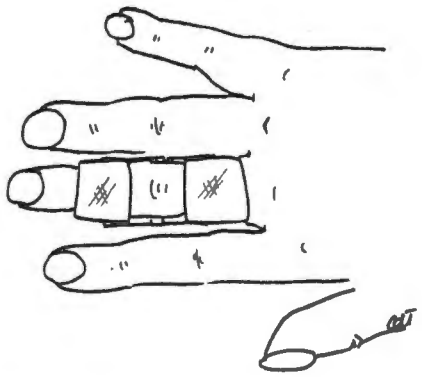


Fig. 10A: Dorsal view of reversed figure-of-eight splint

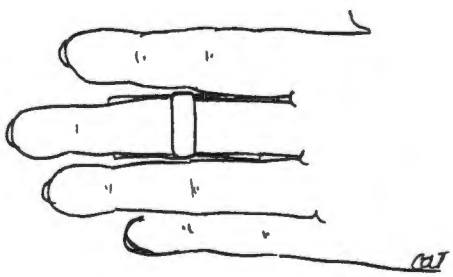


Fig 10B: Ventral view

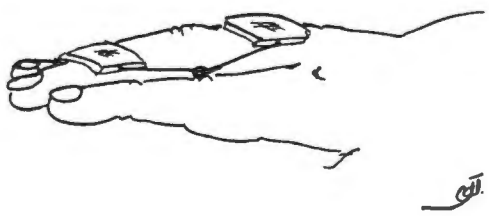


Fig 10C: Side view. Note the three-point pressure system forcing the PIP joint into flexion

Flatt (1983, p.48) suggests another, rather bulky, dynamic splint called the 'knuckle bender' after a similar splint for the MP joint first described by Bunell. Both these splints will however cause constant strain on the joint structures and have the potential to irritate and to cause a joint flare-up. This is a risk, in the opinion of the author, that a therapist treating out-patients cannot take, not being able to check joints and splints daily.

The splint of choice is therefore the PIP hyperextension splint. The reasons can be summarised thus:

(1) By choosing a splint which does not allow the PIP joint to go into hyperextension, the pathological course of the deformity is halted:

With intrinsic tightness as primary underlying cause, the splint maintains the length of the middle slip of the extensor mechanism, by not allowing it to assume a hyperextended position. Disruption of the volar plate of the MP joint, which will cause excessive pull on the middle slip, can be halted in the same way by not allowing hyperextension of the PIP joint. It is clear that the PIP joint should not be treated in isolation but both intrinsic tightness and volar plate disruption should be treated as well. In both instances a volar resting splint, supporting the MP joints and keeping the PIP and DIP joints in slight flexion, could be used (Davis and Janecki, 1978; Philips, 1989).

With a ruptured or frayed flexor digitorum superficialis (FDS) tendon as primary cause, the flexed position of the PIP gives the FDS time to heal in a position of no strain, or at least prevents ultimate rupture or further damage to an already worn tendon.

If a mallet finger is the first sign of a developing swan neck, the best line of action is to provide a mallet finger splint (Van Velze, 1988, p.198). If however secondary evidence of swan neck deformity is evident such as increased pull of the middle slip with relaxation of the lateral bands, the development of the deformity should be halted by putting the PIP joint in slight flexion.

(2) A static splint is preferred to a dynamic splint if the therapist is unable to avoid overstrain of joints and subsequent flare ups. Immobilising RA joints completely may lead to ankylosis (Ellis, 1984); therefore dynamic splints are usually preferred. In the case of the proposed hyperextension splint, however, the patient will be able to mobilise the PIP joint by active flexion and extension.

(3) The splint can be used in activity (Philips, 1989).

5.2 SPLINT DESIGNS FOR BOUTONNIERE DEFORMITY:

For a mild boutonniere, either caused by trauma or because of RA, most authors prescribe a dynamic splint (Nalebuff and Millender, 1975b; Rothwell, 1978; Evans, 1984; Van Velze, 1988, p.198). Rothwell (1978) and Nalebuff and Millender (1975b) advocate the Capener splint (See Fig. 11).

FIG. 11: CAPENER SPLINT

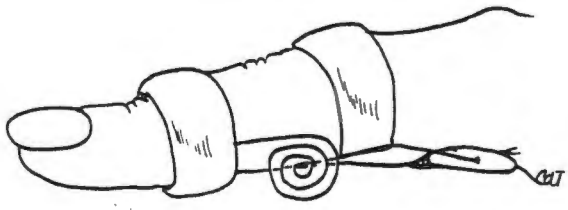


Fig. 11A: Capener splint provides dynamic PIP joint extension by means of a spring wire coil and allows DIP joint flexion.

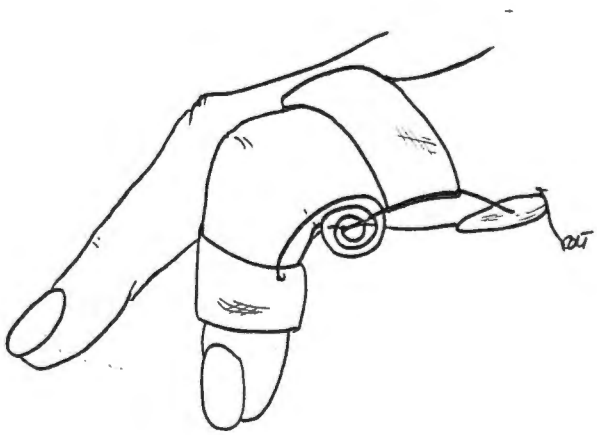


Fig. 11B: Capener splint allows PIP joint flexion against the spring wire coil

Flatt (1983, p.48) is hesitant about supplying a Capener splint because of the difficulty of applying it correctly and maintaining even pressure on the joint. He prefers using the "reversed knuckle bender" (See Fig. 12).

FIG. 12: REVERSED KNUCKLE BENDER SPLINT

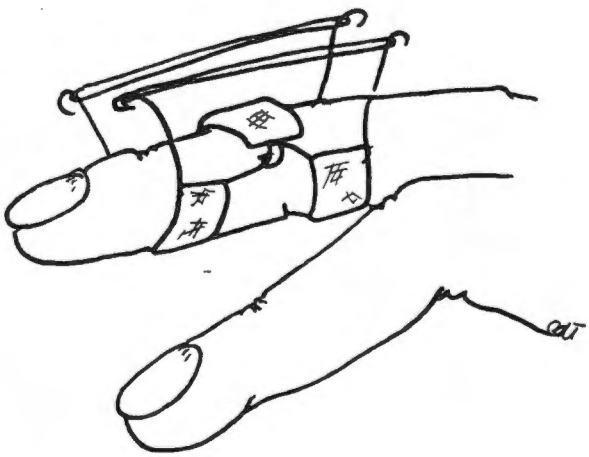


Fig. 12: The reversed knuckle bender encourages PIP joint extension through the use of rubber bands on outriggers.

Malick and Kasch (1984) also advocated great care when considering a dynamic splint for a rheumatoid hand, because of the risk involved when a joint is overstrained by an ill-fitting splint. Callahan and McEntee (1986) designed a lighter, non-bulky, easily custom made splint based on the Capener splint (See Fig. 13).

FIG. 13: THREE-POINT PIP EXTENSION SPLINT

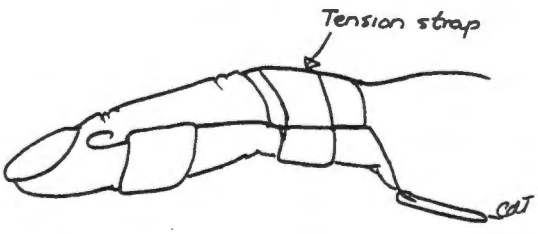


Fig. 13: Three-point PIP joint extension splint of Callahan and McEntee (1986). Note the tension strap fitted volar to the DIP joint.

Ellis (1984) described a figure of eight dynamic splint (see Fig.9), which she also prescribed for excercise purposes for swan neck deformities, for flexion contractures, not stating specifically if it was meant for a boutonniere deformity. This splint provided a three-point pressure system, with the middle point of pressure directly proximal to the PIP joint. Keeping in mind that most boutonnieres arising from RA are accompanied by synovial swelling and pain in the PIP joint region, this splint was considered unsuitable by the author.

Malick and Kasch (1984) prescribed an ordinary plaster cast which kept the PIP joint in extension and at the same time left the DIP joint free to flex. If confronted with a grade II boutonniere deformity, where the Landsmere ligaments are already shortening, active DIP flexion could elongate these ligaments and prevent the worsening of the deformity, provided that the PIP joint is kept in extension,.

The "three-point PIP extension splint" proposed by Callahan and McEntee (1986) (see Fig. 14) was considered by the researcher to be most suitable. The design principles that this splint adheres to correspond well to the prerequisites of splinting the RA joint:

(1) "It is individually fitted to distribute pressure over as wide an area of the finger as possible.

(2) It can easily be removed and refitted by the patient to perform other tasks.

(3) It has a streamlined design acceptable to the patient.

(4) It is readily fabricated using wire which is strong but easily worked and, most important, needs no soldering.

(5) It provides a non-giving non-elastic, gentle force against the resistance of contracted tissues.

(6) The patient can adjust the amount of tension as instructed by the therapist.

(7) Because of its low tension, it can be worn for long periods, thereby conforming to the principle of gentle prolonged stretch". A gentle persistent force is a criterion Flatt (1983, p.48) states as most important in dynamic traction.

When splinting the boutonniere deformity, however stretching of the Landsmeer ligament is an important factor to consider (see p. 35). The three-point PIP extension splint did not allow that, because of the position of the distal volar band. A small adjustment, in that the DIP joint is left free to flex by a more proximally positioned band, could solve this problem (see Fig. 14).

FIG. 14: ADJUSTED THREE-POINT PIP EXTENSION SPLINT

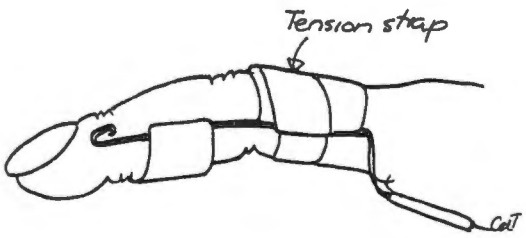


Fig. 14: Adjusted PIP extension splint positions the distal volar strap proximal to the DIP joint to allow DIP flexion and provides an adjustable tension strap dorsal to the middle phalanx.

Although this chosen splint is not a true dynamic splint, it combines the positive factor, namely traction, of the dynamic splint with the safety of the static splint. Compared to the static finger cast, it has the advantage that the patient can remove it when necessary, but while the splint is worn, it takes the pressure off the middle slip and dorsal capsule of the PIP joint, as would a static splint.

5.3 SPLINT PROGRAMMES:

It is remarkable that most advocates of specific splints for RA or other pathologies stress that the patient should be told for how long the splint should be worn and that measures should be taken to achieve compliance, but none of them give any indication of a wearing schedule other than that the patient cannot be asked to wear the splint for 24 hours (Malick and Kasch, 1984, p.136; Ellis, 1984; Pedretti, 1985, p.296; Carter, 1987, p.240;

Philips ,1989; Trombly, 1989, p.365). An exception to this lack of specificity is the splinting post operatively.

As far as resting splints are concerned, most RA patients wear them in the sub-acute stage only at night (Pedretti, 1985, p.294), which accounts for more or less eight hours. Other factors to take into consideration when prescribing the hours per day a splint should be worn, are whether the joint may become stiff in the splint (Pedretti, 1985, p. 296), whether muscles will get adequate exercise in the splint to avoid rapid atrophy (Burke, 1984) and if the person can perform necessary functional tasks while wearing the splint.

The PIP hyperextension splint is not supposed to impede any flexion at the interphalangeal joints, but it is possible that the splinted finger might be inhibited from moving naturally with a foreign object on it. Muscles can unnecessarily waste by the same token. Philips (1989) prescribes this splint only to improve function, and in the author's experience it indeed gives stability to the PIP joint and puts the finger in a position of function. It is therefore advisable that the patient exercises frequently during the day or uses the fingers in daily activity to keep the joints mobile and muscles strong.

The three-point PIP extension splint unfortunately does not allow movement and puts the finger in an awkward extended position. If the PIP joint is not regularly exercised, the joint may indeed become stiff and the muscles weak. Added to this is the risk of irritation of the joint by the traction on the flexors and Landsmeer ligaments.

6. COMPLIANCE IN SPLINT WEARING:

When the merit of splint treatment for RA patients is evaluated, one of the questions to be asked is: how certain can one be that the patient will wear the splint?

From this other questions arise:

(1) How can one measure the compliance of patients and how reliable is this measurement?

(2) What quantitative norm can be set for compliant splint wearing?

(3) Is there any difference in the compliance for different splints?

(4) Can any variables be identified as causal factors for non-compliance in splint wearing in RA?

Different researchers studied the problem of compliance in RA treatment, including splinting. The results in terms of splints are summarised in Table 3.

TABLE 3: SUMMARY OF THE RESULTS OF SPLINT COMPLIANCE RESEARCH:

REFERENCE	% COMPLI-ANCE	METHOD OF MEASURE-MENT	RELIABILITY-OF MEASUREMENT	CRITERIA FOR-COMPLIANCE	TYPE OF SPLINT	FACTOR SEX	FACTOR AGE	FACTOR SOCIAL STATUS	FACTOR TIME ONSET
Feinberg 1981 n=50	62%	-Interview Direct questions	X	50% of prescribed time	Hand resting splint	X	40 to 70 yrs	X	0 to 2 yrs
Nicholas 1982 n=54	80% 77%	-Interview -Splint condition	X	At least a few hours/day	Wrist rest splint	X	X	X	X
Moon 1976 n=38	34%	Weighted average -Self report -GP opinion -SP*	Self vs GP GP vs SP* Self vs SP*	Between "less than half" and "most of the time"	X	X	X	X	X
Oakes 1981 n=66	65%	Direct questions "% time?"	Collateral of family (p=0,01)	50% of the time	Hand resting splint	Women	45yrs and up	Lower group	X
Ferguson 1979 n=17	25%	X	X	more than 3 times per week	X	X	X	X	X

*SP=Specialist

X refers to aspects which were not considered adequately or at all by researchers.

The percentage of compliance varied between 25% and 80% in the different studies. This lack of agreement could be largely attributed to differences in criteria for compliance. Feinberg and Brandt (1981) used the standard of "50% of the prescribed time", but did not state what the prescribed time was.

Moon et al (1976) used a five-point scale, namely 0=none of the time; 1=very seldom; 2=less than half the time; 3=most of the time; 4=all the time. They accepted a score of 2,5 and above as compliant. Oakes et al (1981) used phrases like "50% of the time" which may be 50% of 24 hours, 50% of 16 hours waking time or 50% of the eight-hour norm.

Interpretations of these authors' ideas against a norm of eight out of 24 hours is summarised in Table 4.

TABLE 4: CRITERIA OF COMPLIANCE BROUGHT TO ONE NORM:

REFERENCE	CRITERIUM STATED	IN TERMS OF 8H /24H	IN TERMS OF 24H DAY	IN TERMS OF 16H AWAKE
Feinberg	50% of prescribed time	4h / day	X	X
Nicholas	At least 3 to 4 hours	X	3 to 4 h	3 to 4 h
Moon	"Less than half" to "most of the time"	4h to almost 8 hours	12 hours to almost 24 hours	8 hours to almost 16 hours
Oakes	50% of the time	4 hours	12 hours	8 hours
Ferguson	More than 3 times per week	Not possible to compare		

TABLE 5: AGREEMENT BETWEEN COMPLIANCE MEASUREMENTS:

COMPARISON GROUPS	KAPPA	SIGNIFICANCE
Specialist vs G P	K = 0.5	Not enough information to calculate p-values
Specialist vs Self-report	K = 0.05	
G P vs Self-report	K = 0.02	
REFERENCE: Moon (1976)		

Feinberg and Brandt (1981) and Oakeset et al (1981) arrived at similar results of 62% and 65% compliance. If we assume they used the same criteria, the low 34% of Moon et al (1976) could be explained if they expected the patients to wear the splints much longer than the hours prescribed by the other authors. Nicholas et al (1982) reported a high 77% to 80% compliance, which could possibly be attributed to lesser expectations in terms of time to wear the splint. The study done by Ferguson and Boyle (1979) yielded a low 25% compliance, but because of a total lack of information on the methods used, this study will be ignored for the purposes of this literature review.

A factor which did not receive adequate consideration in the above-mentioned studies, is the method of measuring compliance. Authors tried to achieve a reliable measurement, but few quantified the reliability. Nicholas et al (1982) reported a 3% decrease in compliance score, if the patients' subjective account was ruled out in favour of an objective evaluation of the splint appearance. Both these methods are subjective and could have led to over-estimation of compliance.

Moon et al (1976) used in addition to a questionnaire to the patient, the opinions of the general practitioner (GP) of the patient and the specialist in charge of the clinic. The question could well be asked: on what did the two doctors base their opinion? They probably asked the patient or guessed. These surely are less reliable estimates of the real compliance than the patient's direct self-report. With the available data from the Moon study, Kappa statistics, indicating the degree of agreement beyond chance between the three measurements, were calculated (see Table 5). In light of the fact that the patient's self-report did not agree significantly with either the opinion of the GP or the specialist, both methods were rendered suspect to bias.

Oakes et al (1981) used "independent" collateral information from the families of patients, which showed remarkable agreement with the patients' self-report. From the data Kappa statistics (K=0,46; z=9,6) were calculated being significant on the 1% level. Unfortunately no information on what was done to ensure that reports from family were indeed "independent" was given. Ferguson and Boyle (1979) warned that "family members may have as much of an investment in over reporting of compliance as patients". They studied the compliance to exercise programmes of RA patients, where family members reported complete compliance, while patients themselves admitted to cheating on their exercises. This in itself does not explain the remarkable agreement, but warns against using collateral from family as a "golden standard".

Everything considered, it seems to be much simpler and as reliable as any of the other methods used to obtain compliance data from the patients themselves.

Most of the authors, where it was identified, studied the compliance of patients wearing the total resting splint. Nicholas et al (1982) however referred specifically to the "wrist resting splint" which is probably the one only supporting the wrist and not the whole hand. (See Table 3). It is thus possible that the compliance figure of 62% to 65% is not applicable to the wearing of the PIP-hyperextension splint and the three-point PIP extension splint.

The researchers reached conclusions on the factors that probably influenced the compliance of patients. The value of such indicators is in predicting which patients have a low compliance probability, in order to exclude such patients from randomised clinical trials, or to try to manipulate the factors where possible to achieve compliance. These factors are summarised in Table 6.

TABLE 6: FACTORS INFLUENCING SPLINT WEARING COMPLIANCE

REFERENCE	STUDY TYPE	FACTOR	ASSOCIATION STATISTICS
Feinberg	Crossectional Analytical Survey	Age: 40 to 70 years more compliant	Chi-square=9,34; p=0.05 Significant
		Time between onset of illness and splinting	Chi-square=1,55 Not significant
		Outpatient vs In-patient treatment	Chi-square=0,69 Not significant
Moon	Crossectional Analytical Survey	E.P.I.: Introvert personality more compliant	p=0,039 Significant
			E.P.I. lie scale Significant.*
		Age	Not significant
		Sex	
		Married status	
		Expectations of family	No proof in data or statistics given
		In vs outpatient	
Nicholas	Crossectional Analytical Survey	Sex: Men are less compliant	No statistical proof
Oakes	Prospective Analytical Survey	Family expectations high - compliance high.	Chi-square=14.04; p=0.0002 (Female) Chi-square=11,56; p=0,0006 (Male) Significant

*** Patients lied in completing E.P.I.**

The search for the factors, as depicted in Table 6, is in essence a search for causality. The type of study structure used in research, is therefore important because of possible bias associated with retrospective and cross sectional studies for this purpose (Sackett, 1979). All of the cited studies were analytical studies with no control over the way in which the sample was selected. The samples also suffered from a large drop out of patients. The results should therefore not be regarded as more than factors which could possibly influence compliance.

The study by Oakes et al (1981) confirmed that "family expectations" did have an effect on compliance. They found that the perception of the patient that his/her family expects compliance from him/her, encouraged the patient to wear the splint.

Moon et al (1976) found that certain variables favoured compliance, for example patients 45 years and older, rather than younger ones; patients with lower more than higher socio-economic status and women more than men. Feinberg and Brandt (1981) confirmed that patients between 40 and 70 years of age conformed better than the younger group.

Moon et al (1976) tried to establish a personality type or traits that would be non-compliant by letting patients complete the Eysenck Personality Inventory (EPI) at the same time as they completed the questionnaire about compliance. They did find the group's results on the EPI lie scale to be significant. This confirmed the suspicion that patients were not honest in their self-report. They also found that introvert patients were more compliant than extrovert patients.

Everything considered, it seems that the studies by Oakes et al (1981) and Feinberg and Brandt (1981), in that order, should provide the most reliable results. Added to the fact that their compliance rates agreed strongly, support is lent to the estimate of compliance in splint wearing of 62% to 65% (See Table 3).

Compliance certainly seems to be an important factor to consider when dealing with research on the treatment of the RA patient. It also seems to be impossible to exclude all patients who are a poor risk for compliance from such a study. It would rather be more sensible to ensure that the experimental and control groups were, apart from other considerations, also equal in terms of the factors influencing compliance, such as age, sex and socio-economic status.

7. MEASUREMENT OF CHANGE IN SEVERITY OF DEFORMITY:

When splints are used to stall the development of deformity, it is important to be able to detect differences in severity of deformity with valid and reliable instruments.

7.1 VALIDITY:

Liang and Cullen (1984) felt rather strongly that to assess the success of total joint arthroplasty, it is more valid to measure restoration of function than specific indices such as joint mobility. The reason stated was that patients are often able to function better with their deformities than after arthroplasty. It is obvious that improvement in joint range does not equal better function (Cantrell and Fisher, 1982) because other factors such as motivation and relearning of skilled movement patterns with a "different" hand also play a role in function. If this is so, it must also be true that improvement in hand function does not equal correction of deformity.

A valid measurement of the improvement or deterioration of deformity must have a direct relationship with the objective parameters of defining the deformity. Grading of the deformity, mainly based on the work of Nalebuff and Millender (1975a and b) (see 2.1 and 2.2), is a crude estimate of deterioration in the deformity. Joint mobility was chosen as a more sensitive measure than change in the deformity. Both passive and active range of motion (ROM) were used, to get a more composite picture of the interplay between soft tissue destruction and loss of muscle strength.

Various types of measurement instruments, of which the goniometer in its different forms is the most popular, are discussed in the literature. The

oldest type recorded is the protractor, called the universal goniometer by Hamilton and Lachenbruch (1969). The protractor was very large in comparison with the finger joints. The joint of the goniometer was aligned with the guessed midpoint of the joint and the two arms with the estimated longitudinal axis of the two adjacent bones. This gave rise to inaccuracy.

Hamilton and Lachenbruch (1969) described a "two-piece float and pendulum" goniometer, which consisted of a level structure to be positioned on the proximal bone and a separate piece comprising a 360-degree circle with a freely moving weighted pointer to be placed on the distal bone. Each segment was mounted on a pad designed to fit over the dorsal parts of the digit. The proximal part was levelled and the distal part was allowed to position itself by gravity. This method, however novel it sounds, demanded the use of both hands of the therapist in accurate positioning of the two parts, which left no free hand to stabilise the hand of the patient.

Smaller goniometers were developed especially for use at the digital joints. In these goniometers the joint of the goniometer was placed on the dorsum of the joint, instead of trying to align it laterally to the joint. The ENRAF goniometer is the latest model depicted in more modern literature (Carter, 1987, p.215). Cantrell and Fisher (1982) used an electronic goniometer, which was placed on the dorsum of the digit in the same way.

7.2 RELIABILITY:

Treuhaft et al (1971) obtained a inter-reliability score of 83,9% and 85,7% agreement and intra-reliability score of 85% agreement pooling measurements of MP, PIP and DIP flexion and extension, but did not state the type of goniometer which was used.

Hamilton and Lachenbruch (1969) compared the reliability of three types of goniometers namely the "dorsal finger goniometer", the "universal goniometer and the "two-piece float and pendulum goniometer" for measuring the joints of the hand. Equal reliability among the different goniometers were found, but a small but significant ($p=0.01$) variation between the seven operators was established. This could warn the researcher of a possible weak interrater reliability. The test-retest reliability for each of the seven operators was promising, the largest variance among the operators being 1,5.

Hamilton and Lachenbruch (1969) considered other factors such as too small a space to operate in a grossly deformed hand, oedema, and painful wounds as most important influences on the reliability of measurements. Gajdosik and Bohannon (1987) wrote a literature survey from which they concluded that the most important factor influencing reliability is the accuracy with which the goniometer is handled. These principles were outlined in general by the American Academy of Orthopaedic Surgeons (1965).

If careful consideration is given to the alignment of the goniometer, a reliable measurement should be obtained. For the dorsal finger goniometer, care should be taken that the two arms of the goniometer have maximum contact with the bone segment proximal and distal to the joint, without excessive pressure (Hamilton and Lachenbruch, 1969). Measuring the PIP joint with a swan neck deformity, however, necessitates the placement of the finger goniometer on the volar side of the joint when hyperextension is measured and on the dorsal side when flexion is measured. This leaves room for variation. The problem was not adequately addressed by any of the authors in terms of reliability, although Hamilton and Lachenbruch (1969) acknowledge it as a 'difficulty'.

7.3 RECORDING OF MEASUREMENTS:

The neutral-zero method of recording range of movement (Peskett, 1977; Smith, 1982; Gerhardt, 1989) is widely accepted according to the above named authors. It consists of recording the starting or neutral position that the patient can achieve in the middle, the flexion to the right and the extension to the left. In the same way abduction is recorded to the right and adduction recorded to the left of the starting position. For example:

> A normal MP joint's recording may be 10-0-90. This indicates that the joint can achieve 10 degrees of extension beyond the neutral position; the MP joint is able to assume the neutral position and thirdly MP flexion of 90 degrees.
>
> A boutonniere deformity may appear as a measurement of 0-70-90 at the PIP joint and a measurement of 10-10-10 at the DIP joint. This indicates a stiff ankylosed DIP joint in 10 degrees extension and a PIP joint which is unable to extend to the neutral zero position, but is 70 degrees short of full extension. Flexion up to 90 degrees is achieved.

Gerhardt (1989) stated that this method is ideal for use with computers. It does not allow however room for change over time, if this change involves a dramatic change of a joint which could not assume the neutral position to a joint capable of hyperextension. For example:

> Say the PIP joint range changed from 10 degrees short of full extension to 5 degrees hyperextension and the flexion range stayed at x degrees. With the neutral-zero method the measurements will be recorded as 0-10-x and 5-0-x.
>
> To indicate the total gain in PIP extension it will be erroneous to only subtract the first extension measurement from the last (i.e. 5 - 0 = 5) because the

> total gain in extension was 15 degrees. It would be necessary to add the gain in starting position (which is (0- (-10) = 10) to the gain in hyperextension, (i.e. (0 - (-10) + (5 - 0) = 10 + 5 = 15).

A much simpler method than this is necessary.

It must be noted that some confusion exists because Cantrell and Fisher (1982) described the neutral-zero method as follows: "Any joint in a perfect straight line is regarded as the zero starting point with the maximum major movement of the joint accorded a positive sign and the opposite movement a negative sign." Their examples, which were used to explain this method, did however not correspond with this statement.

8. MEASUREMENT OF STRAIN ON THE HAND:

Cantrell and Fisher (1982) complained about the lack of measurement in clinical trials of how the hands were used in the patients occupations. They endorse the use of "job-descriptions of movements" to explain differences in PIP active ROM between patients.

Platt-Furst et al (1987) designed the ACTRE, an activity record adapted from the "occupational questionnaire" by Kielhofner (1985, p.417) for describing the variability in the levels of activity, daily routines and life roles of arthritic patients. This however was not specific in terms of the influence that activity would have on the hand and development of deformity.

A very specific and sensitive measurement instrument to estimate the amount of strain that the person puts on his or her hand joints by performing certain activities routinely has to be obtained. This instrument would have to distinguish between deforming activity levels that are large enough to influence the prognosis of the deformity.

To develop such an instrument the researcher would have to work from the basic assumption that the joint protection principles (see 4.1) are valid indicators of what should not be done if deformity is to be avoided. They could be used as a basis for deciding which biomechanical factors that can be linked to the performance of activity play a role in the development of deformity. The following aspects can be deduced: the force required of the movement; the range of movement and whether the grasp being used is static or dynamic (See 4.1).

Most kinesiological texts (Lehmkuhl and Smith, 1983, p.211; Tyldesley and Grieve, 1989, p.150) divide the grasps the human hand is capable of into two types, namely the power grasp and the precision grasp. The hand automatically assumes the position for the power grasp, if the optical input conveys the message to the brain that the object to be handled is heavy, and positions itself for the precision grasp if a precise or finely co-ordinated movement is expected (Tyldesley and Grieve, 1989, p.280). The type of grasp may be considered as indicative of the amount of resistance the hand expects to encounter, and therefore a power grasp may cause more deformity than a precision grasp in the RA hand.

An instrument to measure the strain on the RA hand therefore should include an analysis of the activities the patient does regularly according to type of grasp; power of movement; joint range expected and static versus dynamic grasp.

SUMMARY

When a study on splinting for RA is undertaken, it seems to be necessary to take cognisance of a few emerging facts:

1. The illness tends to prevail in certain groups (such as women) more than in others. There are some indications that the disease pattern might differ from group to group.

2. A large number of disease patterns are possible, presumably because of a multitude of known and possibly also unknown prognostic factors which may influence the outcome of the disease.

3. The swan neck and boutonniere deformities can present in different grades and forms.

4. Influences such as activity patterns and hand dominance on the development of deformities, have not been researched conclusively.

5. Many treatment modalities for RA deformities are suggested in the literature. The sections on occupational therapy, such as joint protection and splinting, lack scientific verification.

6. Compliance in splint wearing is low for patients with RA. Therefore the therapeutic results of splints should be presented positively if patients are to be convinced that it is worth their while to wear them. Certain factors such as age, socioeconomic status and personality type could be used to predict the expected compliance of a patient.

7. Measurement of PIP joint range seems to be a widely acceptable method with which to detect differences in deformity.

CHAPTER III

INTRODUCTION

The results obtained from the data analysis will be presented without discussion in three main sections. Firstly two pilot studies, namely on "range of movement" and "strain on hands", will be discussed in full including the research methodology that were used. Secondly the results of the study, as was planned in Chapter I, will be discussed. This will include the sample obtained as well as the allocation of patients to the experimental and control groups. Data on the confounding variables which could possibly influence the comparability of the experimental and control groups will be presented in combination with it. The last and most important section will deal with the results of the experimental group compared with the control group.

The presentation of these results will include three major steps. Firstly the overall results obtained will be stated, followed by the results as they were or were not influenced by the factors "grade of deformity" and "compliance" (refer to Chapter II, p.31, 35 and 60 for the relevance of these two factors). Lastly the results of a comparison between experimental "fingers" versus control "fingers" in the same group of patients will be presented.

The results on swan neck and boutonniere deformities will be presented consecutively but separately in each section.

1. RANGE OF MOVEMENT PILOT STUDY:

Measurement by goniometer of movement range can give rise to different measurement errors contributing to the variation detected in the

measurement (see Chapter I, p.9). In order to establish the extent of variation, a small pilot study was conducted. The proximal interphalangeal (PIP) joints of fingers 2 to 5 of both hands of 30 students were measured (MEASUREMENT 1) by the same person (RATER 1) to establish the normal biological variation that can be expected among different people with regards to PIP joint range. Only active extension and active and passive flexion were measured to save time and because at that stage the researcher did not anticipate a difference in the reliability of active and passive movement.

This measurement was followed up after six months by a measurement (MEASUREMENT 2) of the PIP joints of the eight fingers of 4 students (=32 joints) by RATER 1 as well as at the same occasion measurement of PIP joint range of the same students by the colleague that would assist in collecting the data for the study (RATER 2).

1.1 RECORDING OF MEASUREMENTS:

For the benefit of this study a system other than the neutral-zero method (see Chapter II, p.73) was devised by the author to avoid error as was described earlier (p.74). The neutral position was considered to be 180 degrees. Any hyper-extension achieved was added to 180 and maximum flexion was subtracted from 180 degrees. This method described the joint range as a continuum with 180 degrees coinciding with the straight finger and flexion and extension described as movements in one or the other direction. For example:

> A typical swan neck PIP joint, with 20 degrees hyperextension, and 70 degrees of flexion is recorded as 200-110, showing the exact continuous range of motion as well as maximum end points of flexion and extension achieved. In an attempt to extend, the joint had moved

past 180 degrees up to 200 degrees, which included 20 degrees hyperextension. With flexion, the joint moved from 180 degrees to a position of 110 degrees, indicating a total range of 70 degrees flexion.

1.2 BIOLOGICAL VARIATION IN RANGE OF PIP JOINT MOVEMENT:

The mean PIP joint range for each finger of the right and left hand and corresponding confidence intervals of 95% were calculated, using student-t tables instead of normal tables, due to the small sample (Table 7). These confidence intervals could serve as an estimation of the variability to be expected in the normal sample with regards to the measurements.

TABLE 7: MEAN AND 95% CONFIDENCE INTERVALS OF RANGE OF PIP JOINT RANGE OF THE DIFFERENT FINGERS OF BOTH HANDS

MEASUREMENT	MEAN	STANDARD DEVIATION	CONFIDENCE INTERVAL 95%
ACTIVE EXTENSION			
RIGHT FINGER 2	185.33	7.18	(182.4 ; 188.3)
FINGER 3	188.33	8.69	(184.8 ; 191.9)
FINGER 4	187.83	7.92	(184.1 ; 190.6)
FINGER 5	180.67	4.42	(178.8 ; 182.5)
LEFT FINGER 2	188.00	7.48	(185.0 ; 191.1)
FINGER 3	189.00	7.57	(185.9 ; 192.1)
FINGER 4	188.50	9.05	(184.7 ; 192.2)
FINGER 5	181.17	5.11	(179.1 ; 183.2)
ACTIVE FLEXION			
RIGHT FINGER 2	72.17	5.58	(69.9 ; 74.5)
FINGER 3	73.67	4.46	(71.8 ; 75.5)
FINGER 4	73.83	4.95	(71.8 ; 75.9)
FINGER 5	78.83	6.28	(76.2 ; 81.4)
LEFT FINGER 2	72.3.	4.42	(70.5 ; 74.2)
FINGER 3	74.67	5.31	(72.5 ; 76.9)
FINGER 4	74.17	4.84	(72.2 ; 76.2)
FINGER 5	78.67	6.13	(76.1 ; 81.2)
PASSIVE FLEXION			
RIGHT FINGER 2	64.83	3.53	(63.4 ; 66.3)
FINGER 3	64.83	4.37	(63.0 ; 66.6)
FINGER 4	64.00	4.36	(62.2 ; 65.8)
FINGER 5	65.50	5.82	(63.1 ; 67.9)
LEFT FINGER 2	64.33	4.23	(62.6 ; 66.1)
FINGER 3	64.33	4.23	(62.8 ; 66.1)
FINGER 4	63.83	4.02	(62.2 ; 65.5)
FINGER 5	66.83	4.91	(64.8 ; 68.9)

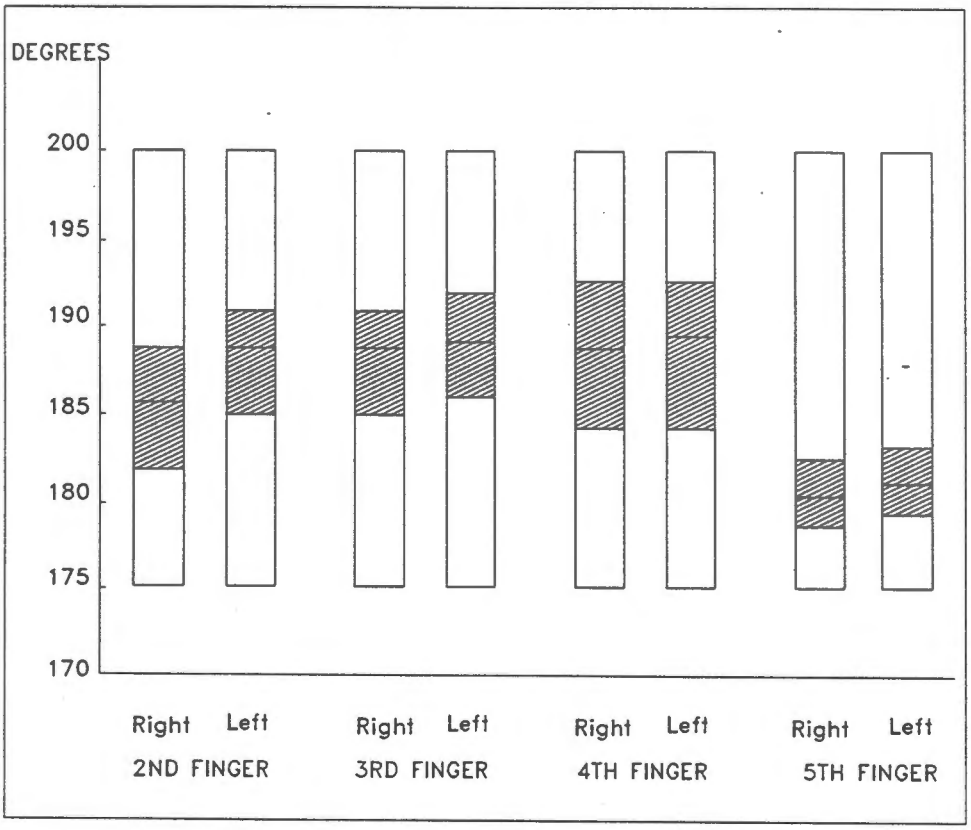
FINGERS 2 TO 5 REFER TO THE INDEX TO THE LITTLE FINGER

For active extension the largest interval was 7.1 degrees (Table 7 and Graph 1). The left and right hands did not differ noticeably.

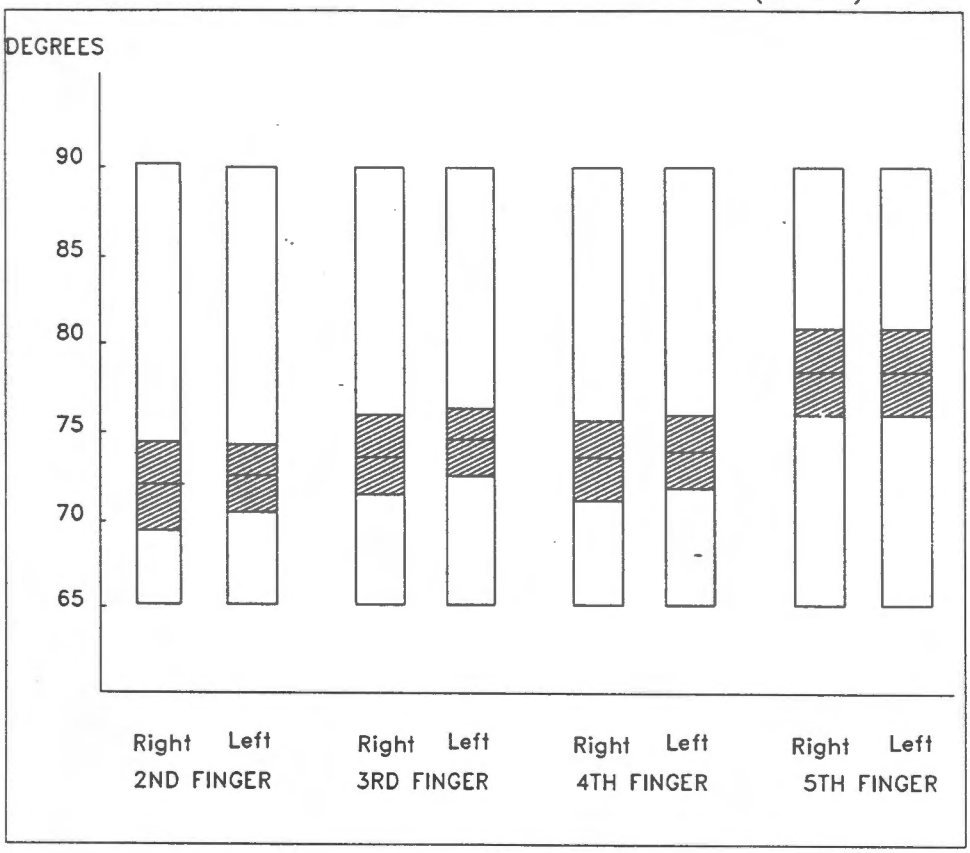
Active flexion of the PIP joint of all eight fingers did not vary for more than 5.2 degrees at most (Table 7 and Graph 2).

The variation of passive flexion was very low with the maximum of a 4.8 degrees confidence interval (Table 7 and Graph 3).

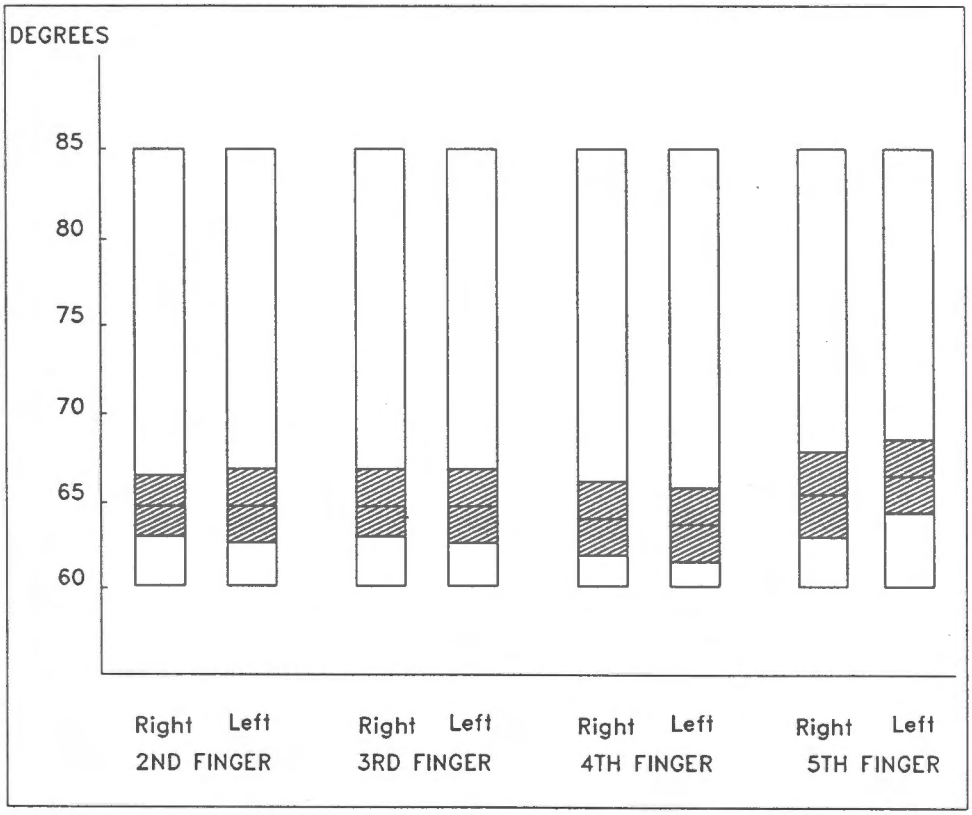
GRAPH 1: MEANS AND 95% CONFIDENCE INTERVALS FOR ACTIVE EXTENSION OF PIP JOINTS (n=30)



GRAPH 2: MEANS AND 95% CONFIDENCE INTERVALS FOR ACTIVE FLEXION OF PIP JOINTS (n=30)



GRAPH 3: MEANS AND 95% CONFIDENCE INTERVALS
OF PASSIVE FLEXION OF PIP JOINTS



1.3 RELIABILITY OF PIP RANGE OF MOVEMENT (ROM) MEASUREMENTS:

TEST RETEST RELIABILITY:

Joint range data of measurement 1 and measurement 2 were compared using Pearson product moment correlation (r). The Spearman Rank correlation (Rs) was used as well because of the sample size (i.e. 4 students = 32 joints) as well as the possibility that the sample might not have a normal distribution (Table 8). These two tests did not produce markedly different results.

TABLE 8: TEST-RETEST RELIABILITY: CORRELATION BETWEEN MEASUREMENT 1 AND MEASUREMENT 2 OF PIP JOINT RANGE (N=32)

MEASUREMENT MODALITY	M1 MEAN (SD)	M2 MEAN (SD)	R	RS	P VALUE
ACTIVE EXTENSION	166.25 (8.57)	168.13 (10.44)	0.899	0.894	0.000
ACTIVE FLEXION	68.28 (3.45)	72.97 (3.50)	0.486	0.396	0.027
PASSIVE FLEXION	64.22 (2.53)	59.22 (3.33)	0.02	0.038	0.832

Test-retest reliability for active extension was high on both the Pearson correlation coefficient (r) and Spearman Rank correlation (Rs). The correlations for active flexion were fairly weak although significant on Rs (p=0.027). The correlations for passive flexion were weak, and constitute practically no correlation at all (Table 8).

A difference of five degrees between the mean range measured at the first and second occasions was found (Table 8).

A closer look at the difference between measurement 1 and 2 reveals that a larger range of movement was consistently achieved at

measurement 2 than measurement 1. In Table 9 this difference is indicated by means of loss and gain of range of movement from the first to the second occasion, not to be confused with the somewhat different way range of movement has been described thus far. For instance in Table 8 the mean range of movement changes from a position of 64.22 to a position of 59.22 for passive flexion, the latter representing a more flexed position (see Chapter II, p.73) than the first mean. In terms of description of 'loss or gain of range' this would indicate a gain of range, although the mean position would seem to decrease.

TABLE 9: TEST-RETEST RELIABILITY: NUMBER OF CHANGES AND EXTENT OF CHANGE OF MOVEMENT FROM MEASUREMENT 1 TO MEASUREMENT 2

MEASUREMENT MODALITY	LOSS OF 10+ DEGREES	LOSS OF 5 DEGREES	RANGE UNCHANGED	GAIN OF 5 DEGREES	GAIN OF 10+ DEGREES	NO.
ACTIVE EXT	1	2	13	9	7	32
ACTIVE FLEX	0	0	8	19	5	32
PASSIVE FLEX	0	1	7	16	8	32
TOTAL NO.	1	3	28	44	20	

INTER-RATER RELIABILITY:

The measurements of RATER 1 and RATER 2 were correlated with the help of again both Pearson product moment correlations (r) and Spearman Rank correlations (Rs). (Table 10) Note that these measurements included passive extension, when at that stage it became clear that the variability of active and passive extension might differ.

TABLE 10: INTERRATER RELIABILITY: CORRELATION BETWEEN MEASUREMENTS OF RATER 1 AND RATER 2 (N=32)

MEASUREMENT MODALITY	RATER 1 MEAN (SD)	RATER 2 MEAN (SD)	r	SPEARMAN Rs	P
ACTIVE EXTENSION	188.13 (10.44)	189.69 (11.45)	0.74	0.726	0.0001
PASSIVE EXTENSION	194.69 (10.6)	199.84 (11.07)	0.831	0.842	0.0000
ACTIVE FLEXION	68.28 (3.45)	65.81 (3.49)	0.414	0.436	0.015
PASSIVE FLEXION	59.22 (3.33)	59.84 (4.15)	0.374	0.365	0.04

r=Pearson product moment correlation coefficient

High correlations for both active and passive extension were accomplished, but fairly weak correlations were found for both active and passive flexion; however Rs was significant (p=0.15 and 0.04) (Table 10).

Again the difference between the means for the two raters was a maximum of five degrees, and in most instances in the region of three degrees (Table 10).

The direction and extent of the differences between the raters were again examined in terms of 'loss' or 'gain' in range of movement from the first to the second rater, as explained earlier.

TABLE 11: INTER-RATER RELIABILITY: NUMBER AND EXTENT OF DIFFERENCE IN RANGE OF MOVEMENT BETWEEN THE FIRST AND SECOND RATER (N=32)

MEASUREMENT MODALITY	LOSS OF 10 OR MORE DEGREES	LOSS OF 5 DEGREES	RANGE UNCHANGED	GAIN OF 5 DEGREES	GAIN OF 10 OR MORE DEGREES	NO.
ACTIVE EXT	4	4	10	8	6	32
PASSIVE EXT	2	1	8	10	11	32
ACTIVE FLEX	0	2	16	11	3	32
PASSIVE FLEX	0	12	12	7	1	32
TOTAL NO.	6	19	46	36	21	

It appears that RATER 2 was inclined to evaluate a larger range of movement than RATER 1 (Table 11).

2. MEASUREMENT OF STRAIN PILOT STUDY:

A means of distinguishing between the strain that different people place on their joints by performing their own peculiar set of regular activities was needed, because the possibility exists that development of deformity might be influenced by the amount of strain to which the joints are subjected, regardless of whether a splint to prevent deformity is worn or not (see Chapter II, p.75).

A list of 32 activities usually performed by people was compiled by piloting an extensive list among colleagues and friends who represented different walks of life. Duplications were scrapped; for example, cutting with scissors in dressmaking and using scissors in the kitchen or for nail care was covered by one item. Care was taken to keep the list as comprehensive as possible. Any omissions discovered at that stage were included, and a space was available for additions while the questionnaire was being used.

The activities were analysed with regards to movement modalities that could have had an influence on the strain of the joints of the hands. These movement modalities are listed in Table 12 along with the inter-quartile ranges for the different modalities as well as the total strain level. Quartiles and medians were used in preference to means and standard deviations because of the very small sample of 14 normal people from whom the data were gathered. At the same time this instrument was also piloted on 37 arthritic patients to establish whether the instrument would be sensitive enough to show up the expected decrease in movement for the arthritic group.

TABLE 12: STRAIN ON HANDS: INTER-QUARTILE RANGES OF DIFFERENT MODALITIES OF STRAIN AS EXPERIENCED BY THE HANDS OF A 'NORMAL' SAMPLE (N=14) AND AN ARTHRITIC SAMPLE (N=37)

	NORMAL SAMPLE			ARTHRITIC SAMPLE		
STRAIN MODALITY	Q1	MEDIAN	Q3	Q1	MEDIAN	Q3
DYNAMIC GRASP	7.5	8.5	9.5	5	7	9
LIGHT MOVEMENT	7.5	9	10.5	6	7	10
INNER RANGE	9.5	11.5	14	6.5	9	12.5
PRECISION GRASP	6	6.5	8.5	4	6	8
LESS STRENOUS ACTIVITY	7.5	9	10.5	5.3	6.8	9.5
STATIC GRASP	10	11.5	13.5	6	8	11
FORCEFUL MOVEMENT	9	9.5	11	5	6	9
OUTER JOINT RANGE	5	5	7	4	5	6
POWER GRASP	11	12	14	6	9	11
STRENUOUS ACTIVITY	9	9.3	11	5	7	9
TOTAL STRAIN LEVEL	7.8	9	11	5	6.5	9

The arthritic group had a lower strain level on all types of movement than the normal group, especially in the strenuous activity section (Table 12 and Graph 5). It was hypothesised that arthritic people who are experiencing pain, would cut down on those activities that strain their arthritic joints.

3. RESULTS OF SCREENING OF THE REFERENCE POPULATION:

Patients were screened at the two rheumatology clinics at Tygerberg Hospital for inclusion in the study according to a set of criteria (see Chapter I, p.3). Screening commenced at the Thursday clinic in January 1989 and tallied 62 in June 1989, when screening at the Tuesday clinic also started, while the numbers at the Thursday clinic dwindled.

Eventually 151 patients were screened for inclusion, of which 75 were from the Thursday clinic and 76 were from the Tuesday clinic.

4. RESULTS OF SAMPLING:

4.1 Initially 49 patients with swan neck deformities and 43 patients with boutonniere deformities were included (Table 13). More of the patients with swan neck deformities came from the Thursday clinic and more patients with boutonniere deformity form the Tuesday clinic (Table 13).

TABLE 13: NUMBER OF PATIENTS INITIALLY INCLUDED IN THE STUDY FROM THE TWO CLINICS WITH EITHER DEFORMITY

	THURSDAY CLINIC	TUESDAY CLINIC	TOTAL
SWAN NECK	28	21	49
BOUTONNIERE	14	29	43
TOTAL	42	50	92

4.2 Most of the patients with swan neck deformities had a grade I deformity (Table 14).

TABLE 14: NUMBER OF PATIENTS WITH SWAN NECK DEFORMITY OF DIFFERENT GRADES WHO WERE INITIALLY INCLUDED IN THE STUDY FROM THE TWO CLINICS

	THURSDAY CLINIC	TUESDAY CLINIC	TOTAL
GRADE I	18	13	31
GRADE II	10	8	18
TOTAL	28	21	49

4.3 The boutonniere deformities were evenly distributed between the two grades of deformity. However, the grade II deformities seemed to be more prevalent in the Tuesday clinic (Table 15).

TABLE 15: NUMBER OF PATIENTS WITH BOUTONNIERE DEFORMITY OF DIFFERENT GRADES WHO WERE INITIALLY INCLUDED IN THE STUDY FROM THE TWO CLINICS

	THURSDAY CLINIC	TUESDAY CLINIC	TOTAL
GRADE I	10	12	22
GRADE II	4	17	21
TOTAL	14	29	43

4.4 Some of the patients included in the sample were lost before adequate follow-up measurements could be taken. This was because of patients who moved away, stopped visiting the clinic, or were lost track of when appointments were not kept or when patients were missed when they arrived without appointment at the clinic. The true sample thus look somewhat different (see Tables 16 to 18).

4.5 The two clinics lost an equal number of patients (compare Tables 13 and 16). The swan neck sample lost eight and seven patients respectively and the boutonniere sample lost four and five patients respectively from the Thursday and Tuesday clinics.

TABLE 16: NUMBER OF PATIENTS EVENTUALLY INCLUDED IN THE STUDY FROM THE TWO CLINICS WITH EITHER DEFORMITY

	THURSDAY CLINIC	TUESDAY CLINIC	TOTAL
SWAN NECK	20	14	34
BOUTONNIERE	10	24	34
TOTAL	30	38	68

4.6 Many more patients with grade I swan neck than grade II swan neck deformities were lost from the study. The distribution of loss between the two clinics was however fairly even (compare Tables 14 and 17).

TABLE 17: NUMBER OF PATIENTS WITH SWAN NECK DEFORMITY OF DIFFERENT GRADES WHO WERE EVENTUALLY INCLUDED IN THE STUDY FORM THE TWO CLINICS

	THURSDAY CLINIC	TUESDAY CLINIC	TOTAL
GRADE I	12	6	18
GRADE II	8	8	16
TOTAL	20	14	34

4.7 As was the case with the swan neck deformities, the boutonniere deformity grade I sample lost more (six patients) than the grade II sample (three patients). The distribution of loss between the two clinics, however was again even (compare Tables 15 and 18).

TABLE 18: NUMBER OF PATIENTS WITH BOUTONNIERE DEFORMITY OF DIFFERENT GRADES WHO WERE EVENTUALLY INCLUDED IN THE STUDY FROM THE TWO CLINICS

	THURSDAY CLINIC	TUESDAY CLINIC	TOTAL
GRADE I	7	9	16
GRADE II	3	15	18
TOTAL	10	24	34

5. RANDOM ALLOCATION OF PATIENTS TO EXPERIMENTAL AND CONTROL GROUPS

5.1 The patients as they were screened and included in the sample were allocated to experimental and control groups according to the balanced block randomisation (Chapter I, p.5). This system provided a means for digressing from pre-established random allocations in order to keep a more or less equal number of patients from the different grades of deformity in the experimental and control groups, and as far as possible also to balance the distribution of patients from the two clinics between the experimental and control groups (see Appendix 3 for allocation sheet).

On two known occasions the researcher digressed from this system. Firstly the prepared allocation sheet became full during an exceptionally large Tuesday clinic and the researcher had to estimate which allocations would be appropriate. Secondly two patients that were allocated to the experimental groups refused the splints and were allocated to the matching control groups, but both were subsequently lost from the sample.

5.2 More patients with swan neck deformities were allocated to the experimental group from the Thursday clinic and more patients with swan neck deformities from the Tuesday clinic were allocated to the control group (Table 19).

TABLE 19: NUMBERS OF PATIENTS WITH SWAN NECK DEFORMITIES INITIALLY ALLOCATED TO EXPERIMENTAL AND CONTROL GROUPS FROM THE TWO CLINICS.

	EXPERIMENTAL GROUP	CONTROL GROUP	TOTAL
THURSDAY CLINIC	16	12	28
TUESDAY CLINIC	9	12	21
TOTAL	25	24	49

5.3 More patients with boutonniere deformities from the Tuesday clinic were allocated to the control group. This difference is also reflected in the larger control group (Table 20).

TABLE 20: NUMBERS OF PATIENTS WITH BOUTONNIERE DEFORMITY INITIALLY ALLOCATED TO EXPERIMENTAL AND CONTROL GROUPS FROM THE TWO CLINICS

	EXPERIMENTAL GROUP	CONTROL GROUP	TOTAL
THURSDAY CLINIC	7	7	14
TUESDAY CLINIC	12	17	29
TOTAL	19	24	43

5.4 The loss of patients described earlier caused this distribution of patients in the control and experimental groups to change. Equal numbers of patients from the experimental and control groups were lost at the Thursday clinic, but more control patients were lost at the Tuesday clinic (compare Tables 19 and 21).

TABLE 21: NUMBERS OF PATIENTS WITH SWAN NECK DEFORMITY EVENTUALLY ALLOCATED TO EXPERIMENTAL AND CONTROL GROUPS FROM THE TWO CLINICS

	EXPERIMENTAL GROUP	CONTROL GROUP	TOTAL
THURSDAY CLINIC	12	8	20
TUESDAY CLINIC	7	7	14
TOTAL	19	15	34

5.5 The loss from the boutonniere deformity sample was less evenly distributed. The Thursday clinic lost four patients from the experimental group and the Tuesday clinic lost five patients from the control group (compare Tables 20 and 22).

TABLE 22: NUMBERS OF PATIENTS WITH BOUTONNIERE DEFORMITY EVENTUALLY ALLOCATED TO EXPERIMENTAL AND CONTROL GROUPS FROM THE TWO CLINICS

	EXPERIMENTAL GROUP	CONTROL GROUP	TOTAL
THURSDAY CLINIC	3	7	10
TUESDAY CLINIC	12	12	24
TOTAL	15	19	34

5.6 The different grades of swan neck deformity were initially evenly spread between the experimental and control groups (Table 23).

TABLE 23: NUMBERS OF PATIENTS WITH DIFFERENT GRADES OF SWAN NECK DEFORMITY INITIALLY ALLOCATED TO EXPERIMENTAL AND CONTROL GROUPS

	EXPERIMENTAL GROUP	CONTROL GROUP	TOTAL
GRADE I	15	16	31
GRADE II	9	9	18
TOTAL	24	25	49

5.7 The number of patients with alternate grades of boutonniere deformity differed not more than two in the case of both grades, but had a total of three more in the control group (Table 24).

TABLE 24: NUMBERS OF PATIENTS WITH DIFFERENT GRADES OF BOUTONNIERE DEFORMITY INITIALLY ALLOCATED TO EXPERIMENTAL AND CONTROL GROUPS

	EXPERIMENTAL GROUP	CONTROL GROUP	TOTAL
GRADE I	10	12	22
GRADE II	10	11	21
TOTAL	20	23	43

5.8 Loss of patients from the swan neck sample mainly affected the balance in the grade I subgroup, where more patients from the control group was lost (compare Tables 23 and 25).

TABLE 25: NUMBERS OF PATIENTS WITH DIFFERENT GRADES OF SWAN NECK DEFORMITY EVENTUALLY ALLOCATED TO EXPERIMENTAL AND CONTROL GROUPS

	EXPERIMENTAL GROUP	CONTROL GROUP	TOTAL
GRADE I	11	7	18
GRADE II	8	8	16
TOTAL	19	15	34

5.9 The loss of four patients from the grade I boutonniere experimental group compared to two patients from the matching control group increased the difference between the experimental group and control group by three in the control group; hence the difference of four (compare Tables 24 and 26).

TABLE 26: NUMBERS OF PATIENTS WITH DIFFERENT GRADES OF BOUTONNIERE DEFROMITY EVENTUALLY ALLOCATED TO EXPERIMENTAL AND CONTROL GROUPS

	EXPERIMENTAL GROUP	CONTROL GROUP	TOTAL
GRADE I	6	10	16
GRADE II	9	9	18
TOTAL	15	19	34

5.10 Henceforth when referring to "the sample" the eventual sample and not the initial sample is implied.

6 CHARACTERISTICS OF THE SUBGROUPS OF THE SAMPLE:

6.1 Very few males (nine in a total of 68) were included in the sample. This represented a male:female ratio of 1:6.6. The highest percentage of males (21%) was found in the swan neck experimental group. The group consisted of 14% more males than the swan neck control group. The boutonniere experimental group and boutonniere control groups differed with regard to the number of males, with 2.8% in 'favour' of the boutonniere control group. This difference in percentage in fact represented two males per group, but because of the difference in number of people per group, the percentages differed (Table 27).

6.2 Very few left handed people, five in total, were included in the sample. The difference between the swan neck experimental and swan neck control groups as well as the boutonniere experimental and boutonniere control groups were at most one person (Table 27).

6.3 A comparable percentage of dominant-hand fingers were included in the swan neck experimental group and swan neck control group, but the boutonniere experimental group had 9.8% more dominant hands than the boutonnniere control group (Table 27). More dominant hands were included in the swan neck samples than the boutonniere samples (Table 27).

6.4 Strikingly similar mean ages were achieved between the swan neck experimental and swan neck control groups (Table 27), with a comparable distribution around the median age (Graph 4). The swan neck groups were markedly older than the boutonniere groups (Table 27 and Graph 4).

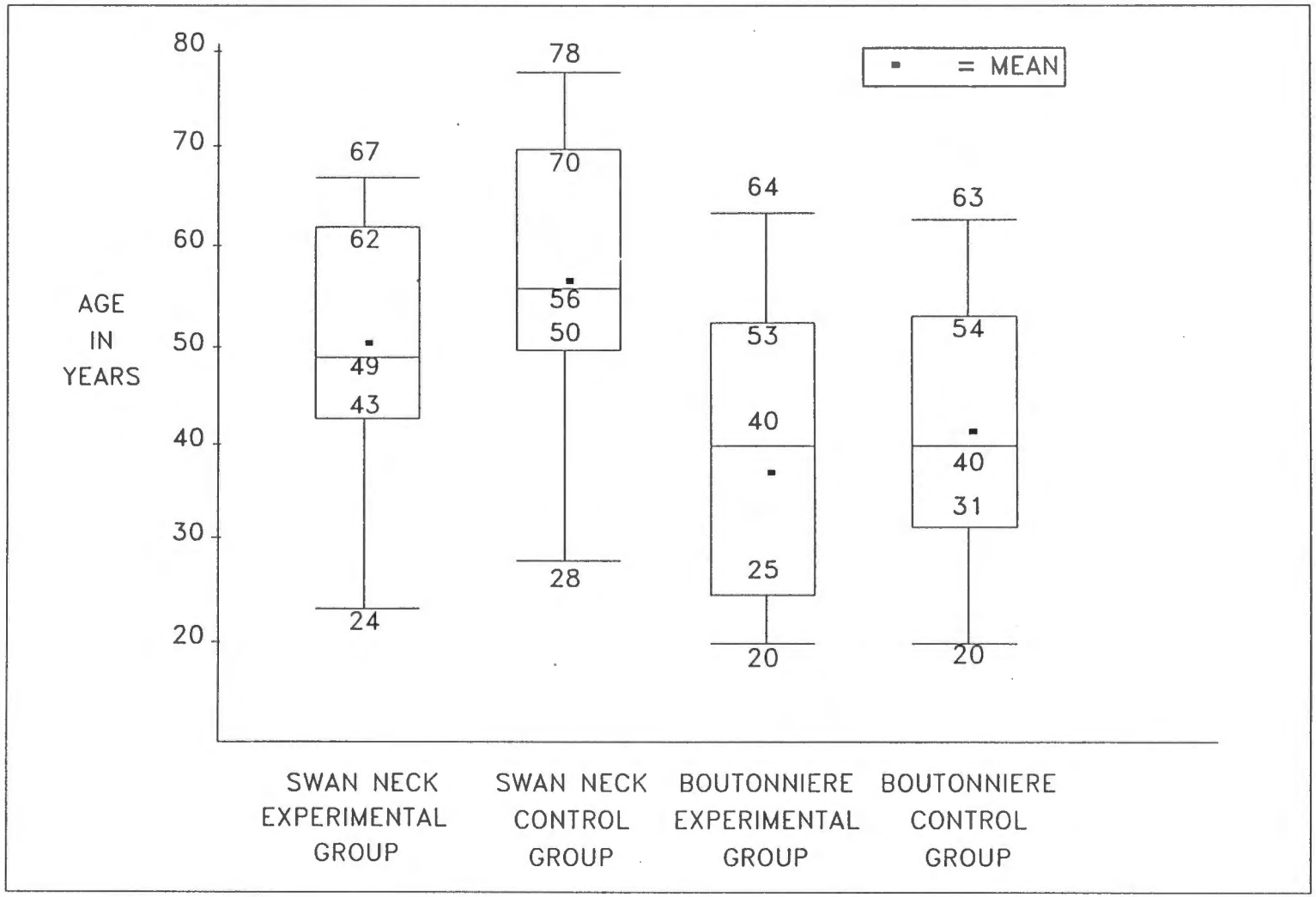
6.5 Comparing the mean total strain score of the swan neck experimental and swan neck control groups, it was noted that the experimental group had a higher score, i.e. exposed their joints to more strain, than the control group (Table 27). This difference in mean was not significant (t-test, p=0.25). The boutonniere experimental group had a lower mean strain score than the control group, but this difference was likewise not significant (p=0.16) (Table 27). The difference in magnitude of strain scores between the experimental and control groups appeared to be smaller than the difference between a normal population and any of the study groups (Graph 5). See also "pilot study on strain on hands" earlier.

TABLE 27: CHARACTERISTICS OF THE SUB-GROUPS OF THE SAMPLE

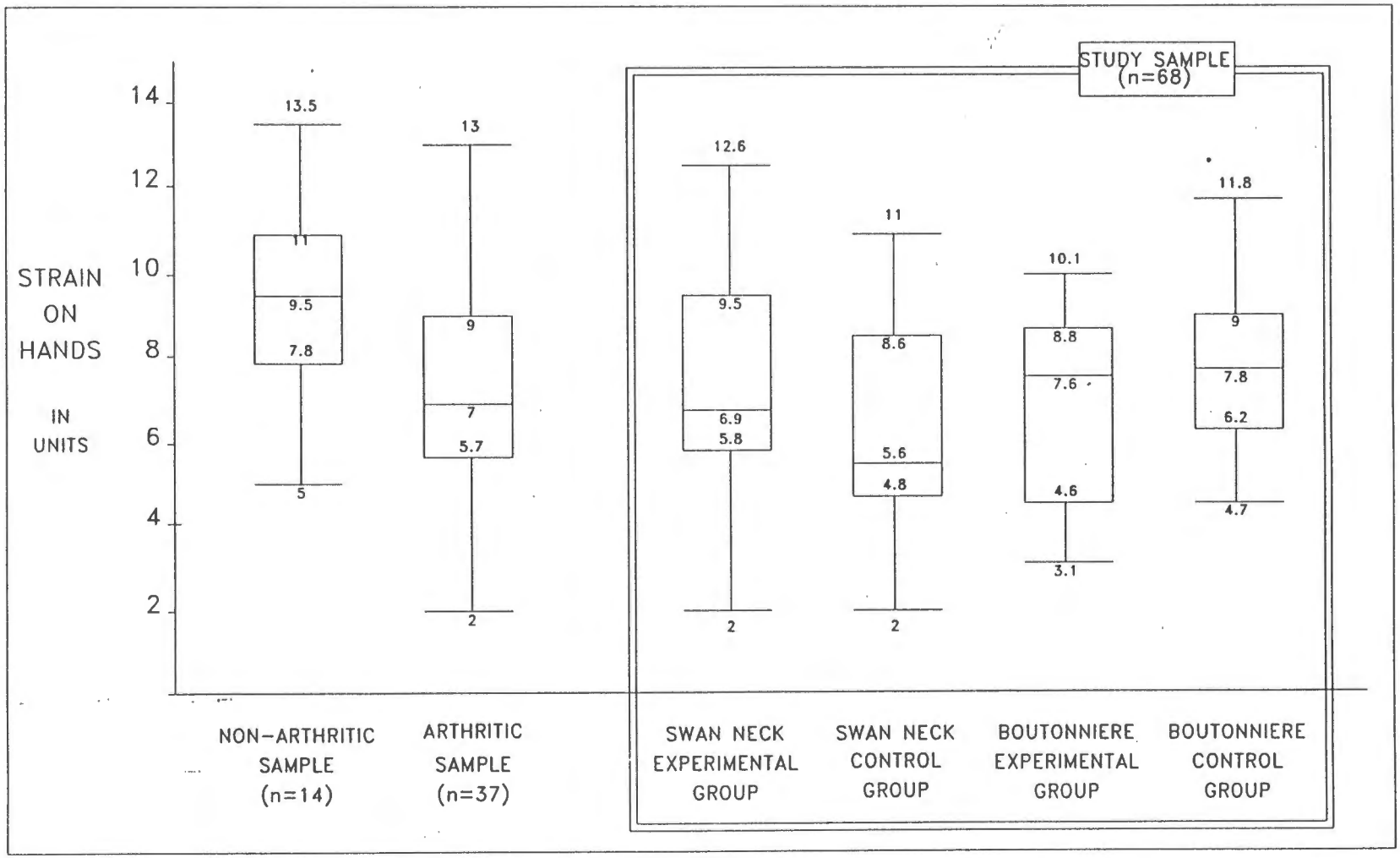
ATTRIBUTES	SWAN NECK EXPERIMENTAL GROUP	SWAN NECK CONTROL GROUP	BOUTONNIERE EXPERIMENTAL GROUP	BOUTONNIERE CONTROL GROUP
NUMBER OF MALES % OF MALES	4 21.0%	1 6.6%	2 13.3%	2 10.5%
NO. LEFT HANDED % LEFT HANDED	2 10.5%	2 14.2%	0 0%	1 5.2%
% WHOSE DOMINANT HAND IS INCLUDED IN THE STUDY	52.6%	57.1%	46.6%	36.8%
MEAN AGE (SD)*	50.1 (12.1)	56.5 (15.1)	38.8 (15.0)	41.7 (12.8)
MEAN STRAIN SCORE (SD)*	60.6 (22.1)	51 (21.0)	55.0 (17.5)	63.4 16.6)
STRAIN P-VALUES	P=0.25		P=0.16	

*SD=STANDARD DEVIATION

GRAPH 4: BOX AND WHISKER PLOTS OF AGE DISTRIBUTION IN THE SAMPLE SUBGROUPS



GRAPH 5: OVERALL STRAIN ON HANDS: A COMPARISON BETWEEN THE SAMPLE SUBGROUPS AND BETWEEN A NON- ARTHRITIC SAMPLE AND THE STUDY SAMPLE



7. THE SAMPLE OF PATIENTS WITH BOTH AN EXPERIMENTAL AND CONTROL FINGER

Those patients allocated to the experimental group who had a comparable deformity in a finger of the opposite hand, were used as another sample of a somewhat different nature (see p.78). This sample had the potential of ruling out the influence of prognostic factors which were inherent to the person and could have something to do with the physical or psychological makeup of the patient.

7.1 SWAN NECK SAMPLE OF EXPERIMENTAL AND CONTROL FINGERS:

Most of the patients (72.7%) came from the Thursday clinic. The grade I and grade II deformities were almost equal in number (six and five respectively) and so was the number of dominant versus non-dominant hands that received the splinting (5 and 6 respectively)

7.2 BOUTONNIERE SAMPLE OF EXPERIMENTAL AND CONTROL FINGERS:

Most of the patients (77.7%) came from the Tuesday clinic. More patients (66.6%) had a grade II boutonniere deformity and in 66.6% of the cases the non-dominant hand was the one that was splinted.

8 RESULTS OF THE SPLINT PROGRAMMES:

8.1 To establish the success of the splint programme for swan neck and boutonniere defromities, two comparisons could be made. Firstly the number of patients changing from one grade of deformity to the next could be compared for the experimental and control groups and secondly the change in joint mobility of the PIP joints of the fingers included in the experimental and control groups could be compared (See Chapter 1, p.8). The first option was ruled out for statistical reasons because only one grade II swan neck deformity from the control group changed to a grade III swan neck deformity. Five boutonniere deformity patients changed their grade of deformity only to change back at the next visit to the original grade.

8.2 To analyse the change in joint range, two approaches could be taken: the first to analyse the magnitude of difference from the first to the last measurement for the different groups and secondly to compare the longitudinal change in time profile. Both methods were used.

8.3 In the first instance an analysis was made of the difference between the first and last measurement of PIP joint range, ignoring the time interval between them, but adjusting the difference for the first measurement , using covariance analysis. This adjustment allowed for differences between patients at baseline. For instance, a hyperextension of 200 degrees has less of a chance to increase than a hyperextension of 185 degrees. The mean difference (i.e change in range) of the experimental and control groups were compared with regards to five measurement modalities, namely resting position; passive extension; active extension; passive flexion and active flexion.

8.4 The other approach takes account of the longitudinal nature of the data, and analysis of variance was used on the data obtained at different points in time. The actual time period between measurements was ignored, and all patients with a minimum of four measurements were included.

9. RESULTS FOR SWAN NECK DEFORMITIES:

9.1 CHANGE IN JOINT RANGE OF PIP JOINTS:

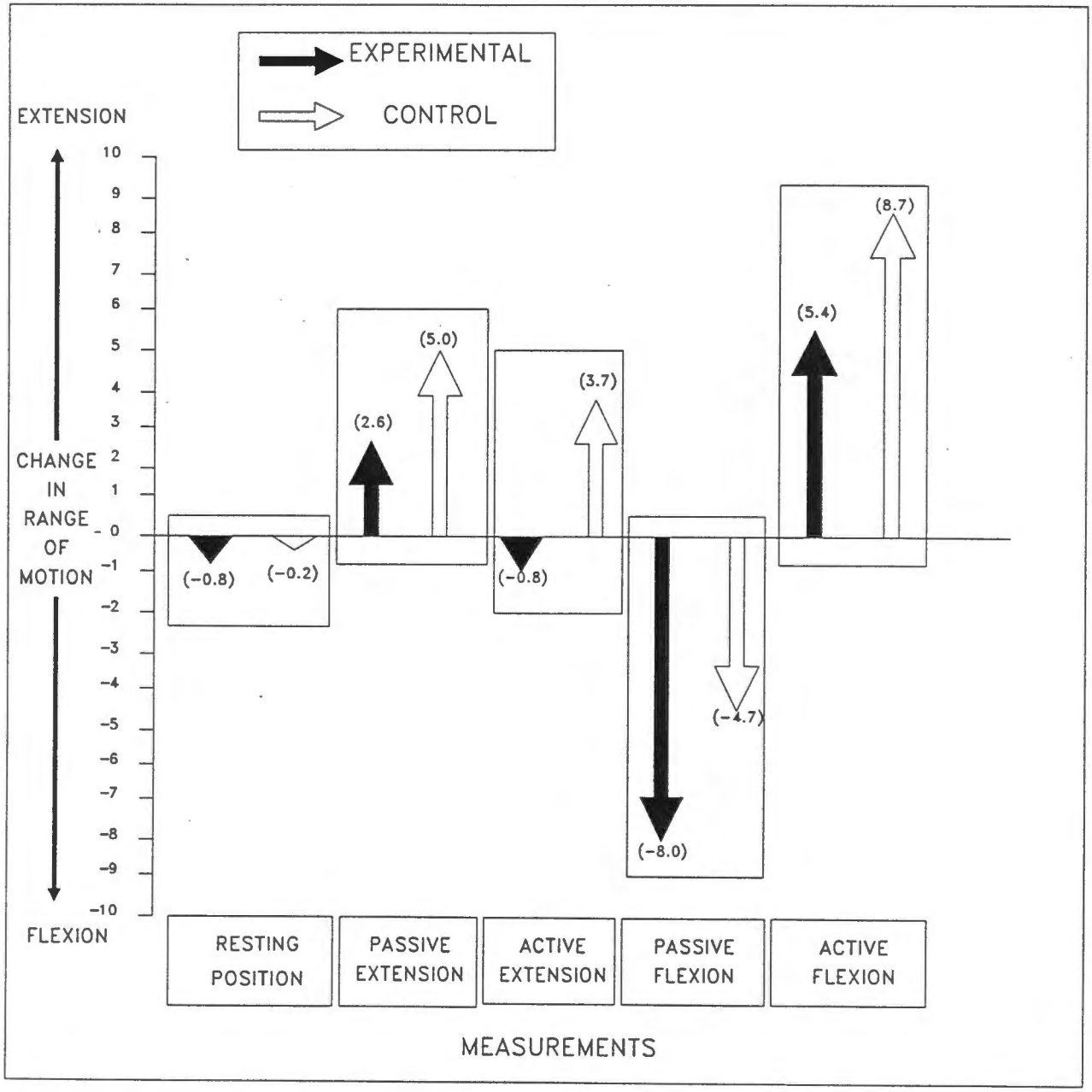
9.1.1 The only significant difference in mean change of joint range between the swan neck experimental and control groups was in terms of active extension ($p=0.044$), where the swan neck experimental group experienced a decrease in active extension and the swan neck control group an increase in active extension. (Table 28 and Graph 6). Because the PIP joint of the swan neck deformity is per definition hyperextended (Chapter II, p.23), the above could be rewritten as "a decrease in active hyperextension" for the swan neck experimental group and an "increase in hyperextension" for the control group.

Although no further statistically significant differences were obtained, certain tendencies became apparent. The swan neck experimental group's mean increase in passive hyperextension was less than the swan neck control group's; more passive flexion was gained by the swan neck experimental group than the swan neck control group, while active flexion of the swan neck experimental group was less impeded than that of the control group (Graph 6).

TABLE 28: MEAN DIFFERENCE (SE) OF PIP JOINT RANGE OF SWAN NECK DEFORMITY: (LAST - FIRST) MEASUREMENT, ADJUSTED FOR THE FIRST MEASUREMENT USING COVARIANCE ANALYSIS

MEASUREMENT MODALITY	SWAN NECK EXPERIMENTAL	SWAN NECK CONTROL	P-VALUE
RESTING POSITION	-0.884 (1.462)	-0.213 (1.651)	0.766
PASSIVE EXTENSION	2.604 (1.691)	5.034 (1.905)	0.349
ACTIVE EXTENSION	-0.813 (1.442)	3.763 (1.624)	0.044
PASSIVE FLEXION	-8.087 (2.689)	-4.739 (3.142)	0.429
ACTIVE FLEXION	5.405 (3.828)	8.736 (4.475)	0.580

GRAPH 6: CHANGES IN PIP JOINT RANGE (LAST – FIRST) MEASUREMENT FOR SWAN NECK DEFORMITIES: A COMPARISON BETWEEN EXPERIMENTAL AND CONTROL GROUPS



9.1.2 The alternate approach analysing the difference in profile changes did not show any significant difference between the swan neck experimental and swan neck control groups for any of the measurement modalities (Table 29). This approach necessitated the further loss of seven patients from the sample available for analysis because they had fewer than four measurements. As no general pattern could be distinguished in the profiles thus obtained, this analysis was dropped in favour of the other approach.

TABLE 29: LONGITUDINAL DATA OF SWAN NECK DEFORMITY: COMPARING PROFILES OF CHANGES IN MEAN RANGE (SE) OF EXPERIMENTAL AND CONTROL GROUPS (N=27)

MEASUREMENS	1	2	3	4	P-VALUE
RESTING POSITION					
EXPERIMENTAL	4.58 (2.09)	3.33 (2.78)	3.75 (2.71)	2.92 (2.46)	0.7012
CONTROL	8.33 (1.87)	5.00 (2.49)	7.33 (242)	7.67 (2.20)	
PASSIVE EXTENSION					
EXPERIMENTAL	15.83 (3.64)	16.25 (3.28)	15.83 (3.37)	18.75 (3.28)	0.4356
CONTROL	22.67 (3.26)	25.33 (2.93)	24.67 (3.02)	23.67 (2.93)	
ACTIVE EXTENSION					
EXPERIMENTAL	9.58 (2.75)	10.00 (2.58)	10.42 (2.80)	10.92 (2.97)	0.9487
CONTROL	14.93 (2.46)	15.00 (2.31)	16.67 (2.51)	16.00 (2.65)	
PASSIVE FLEXION					
EXPERIMENTAL	94.17 (5.64)	87.50 (4.63)	85.00 (4.59)	89.17 (4.60)	0.8678
CONTROL	99.00 (5.05)	90.00 (4.14)	90.33 (4.11)	91.00 (4.12)	
ACTIVE FLEXION					
EXPERIMENTAL	100.83 (5.46)	97.50 (3.76)	97.50 (5.28)	101.25 (5.18)	0.8072
CONTROL	106.00 (4.89)	97.50 (3.37)	97.50 (4.72)	101.25 (4.63)	

SE= STANDARD ERROR

FOR" RESTING POSITION" AND" EXTENSION" DATA ARE GIVEN AS THE DEVIATIONS FROM 180 DEGREES

9.2 CHANGES IN PIP JOINT RANGE OF GRADE I DEFORMITY:

No significant differences between experimental and control groups were found when looking at grade I swan neck deformity (Table 30).

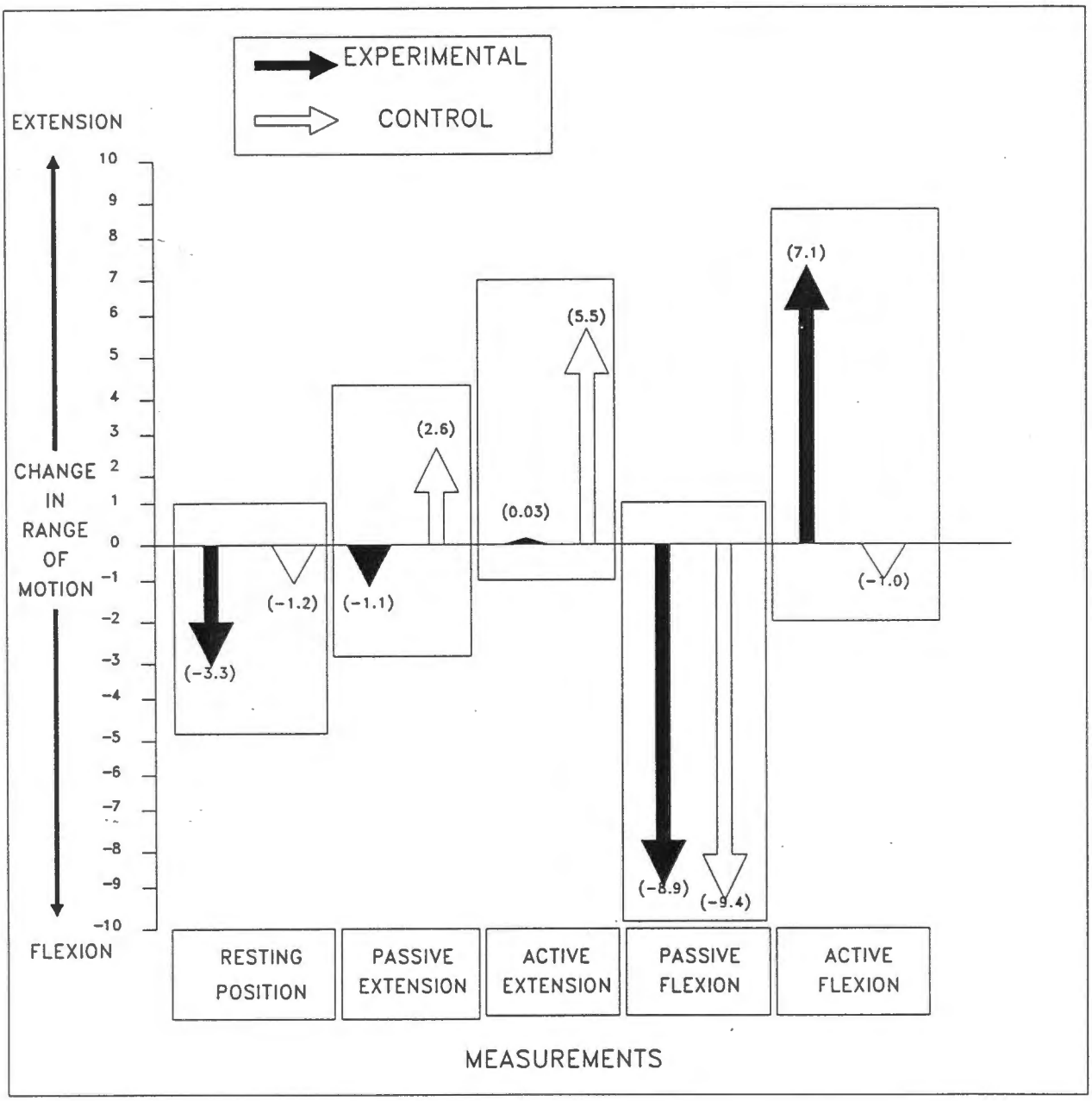
Insignificant, but evident tendencies were: The swan neck grade I experimental group's PIP joints rested in a less hyperextended position than the swan neck grade I control group; a decrease in passive extension of the grade I experimental group and an increase in passive extension of the grade I control group as well as a smaller increase in active extension of the experimental group than the control group were achieved. Active flexion of the experimental grade I group was decreased while active flexion of the control grade I group was slightly increased (Graph 7).

TABLE 30:MEAN DIFFERENCE (SE) OF PIP JOINT RANGE OF SWAN NECK GRADE I DEFORMITY: (LAST - FIRST) MEASUREMENT. ADJUSTED FOR THE FIRST MEASUREMENT USING COVARIANCE ANALYSIS

MEAUREMENT MODALITIES	GRADE I EXPERIMENTAL	GRADE I CONTROL	P-VALUE
RESTING POSITION	-3.367 (1.885)	-1.286 (2.231)	0.494
PASSIVE EXTENSION	-1.163 (2.136)	2.628 (2.543)	0.291
ACTIVE EXTENSION	0.035 (2.395)	5.551 2.854)	0.181
PASSIVE FLEXION	-8.945 (2.279)	-9.477 (2.747)	0.891
ACTIVE FLEXION	7.190 (3.274)	-1.066 (3.954)	0.163

SE= STANDARD ERROR

GRAPH 7: CHANGES IN PIP JOINT RANGE (LAST – FIRST) MEASUREMENT FOR GRADE I SWAN NECK DEFORMITIES: A COMPARISON BETWEEN EXPERIMENTAL AND CONTROL GROUPS



9.3 CHANGES IN PIP JOINT RANGE OF GRADE II SWAN NECK DEFORMITY

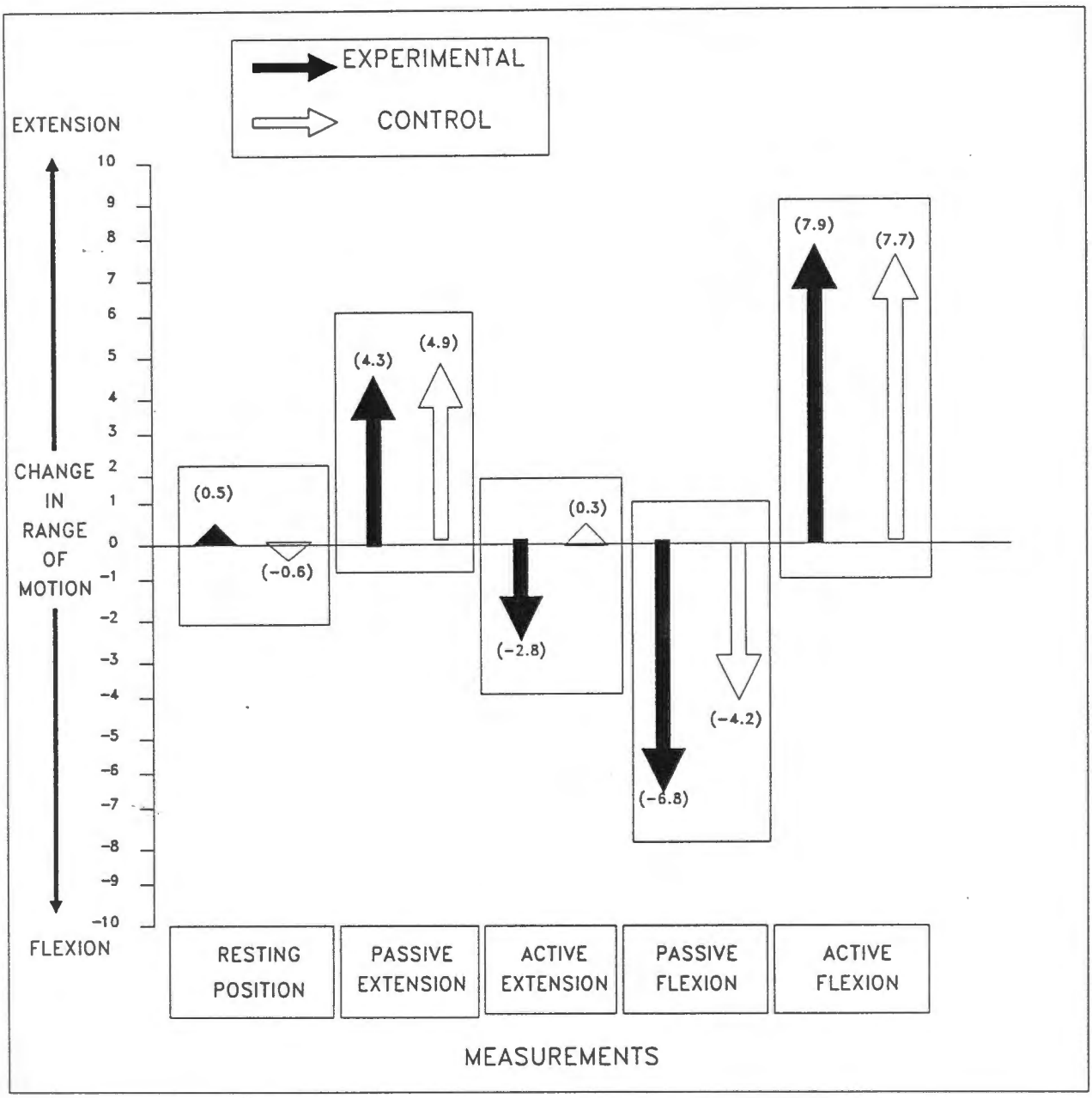
No significant differences between the swan neck grade II experimental group and the swan neck grade II control group were found (Table 31). The emerging pattern, however, was: a decrease in active hyperextension in the experimental grade II group and an increase in active hyperextension in the control grade II group as well as a bigger increase in passive flexion in the experimental grade II group than the control grade II group. Both the experimental grade II and control grade II groups experienced a decrease in active flexion (Graph 8).

TABLE 31: MEAN DIFFERENCE (SE) OF PIP JOINT RANGE OF GRADE II SWAN NECK DEFORMITY: (LAST - FIRST) MEASUREMENT, ADJUSTED FOR THE FIRST MEASUREMENT USING COVARIANCE ANALYSIS

MEASUREMENT MODALITY	GRADE II EXPERIMENTAL	GRADE II CONTROL	P-VALUE
RESTING POSITION	0.553 (2.236)	-0.632 (2.399)	0.731
PASSIVE EXTENSION	4.396 (2.932)	4.976 (3.139)	0.896
ACTIVE EXTENSION	-2.828 (2.618)	0.375 (2.802)	0.424
PASSIVE FLEXION	-6.830 (4.286)	-4.227 (4.925)	0.699
ACTIVE FLEXION	7.969 (4.531)	7.708 (5.232)	0.970

SE=STANDARD ERROR

GRAPH 8: CHANGES IN PIP JOINT RANGE
(LAST – FIRST) MEASUREMENT FOR GRADE II SWAN NECK
DEFORMITIES: A COMPARISON BETWEEN
EXPERIMENTAL AND CONTROL GROUPS



9.4 CHANGES IN PIP JOINT RANGE COMPARING COMPLIANT AND NON-COMPLIANT PATIENTS FROM THE EXPERIMENTAL GROUP:

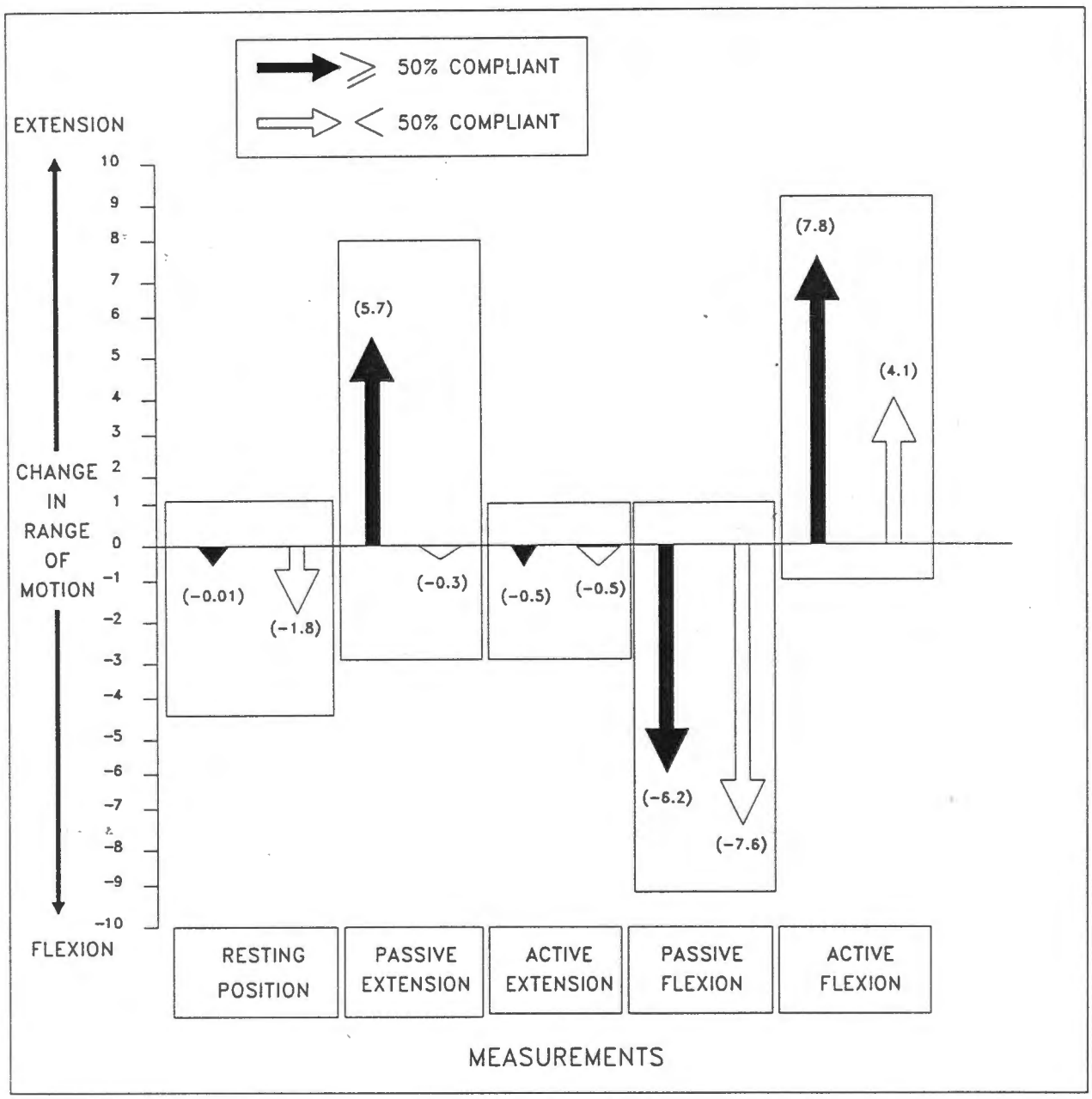
A parameter of 50% compliance was established for patients who reported wearing the splint for 50% of the days since the previous visit, ignoring the time per day that the splint was worn. No significant differences with regards to changes in joint motion between the compliant and non-compliant groups were found (Table 32). The general tendency that had been evident thus far was reversed, in that passive hyperextension in the compliant group was increased whilst the compliant group achieved a smaller increase in passive flexion and a larger decrease in active flexion than the non-compliant group (Graph 9).

TABLE 32: MEAN DIFFERENCE (SE) OR PIP JOINT RANGE OF SWAN NECK DEFORMITY: (LAST - FIRST) MEASUREMENT, ADJUSTED FOR THE FIRST MEASUREMENT USING COVARIANCE ANALYSIS (A COMPARISON BETWEEN COMPLIANT AND NON-COMPLIANT PATIENTS

	SWAN NECK EXPERIMENTAL GROUP		
MEASUREMENTS	COMPLIANT	NON-COMPLIANT	P-VALUE
RESTING POSITION	-8.018 (2.320)	-1.851 (2.711)	0.616
PASSIVE EXTENSION	5.719 (2.620)	-0.363 (3.079)	0.155
ACTIVE EXTENSION	-0.519 (1.983)	-0.537 (2.352)	0.995
PASSIVE FLEXION	-6.278 (3.293)	-7.616 (3.867)	0.796
ACTIVE FLEXION	7.674 (4.425)	4.173 (5.209)	0.600

COMPLIANT=WEARING SPLINT 50% OF DAYS SINCE PREVIOUS VISIT

GRAPH 9: CHANGES IN PIP JOINT RANGE (LAST – FIRST) MEASUREMENT FOR SWAN NECK DEFORMITIES: COMPARING MORE THAN 50% COMPLIANT WITH LESS THAN 50% COMPLIANT PATIENTS



9.5 CHANGES IN PIP JOINT RANGE COMPARING ONLY THE COMPLIANT PATIENTS FROM THE EXPERIMENTAL GROUP WITH THE CONTROL GROUP.

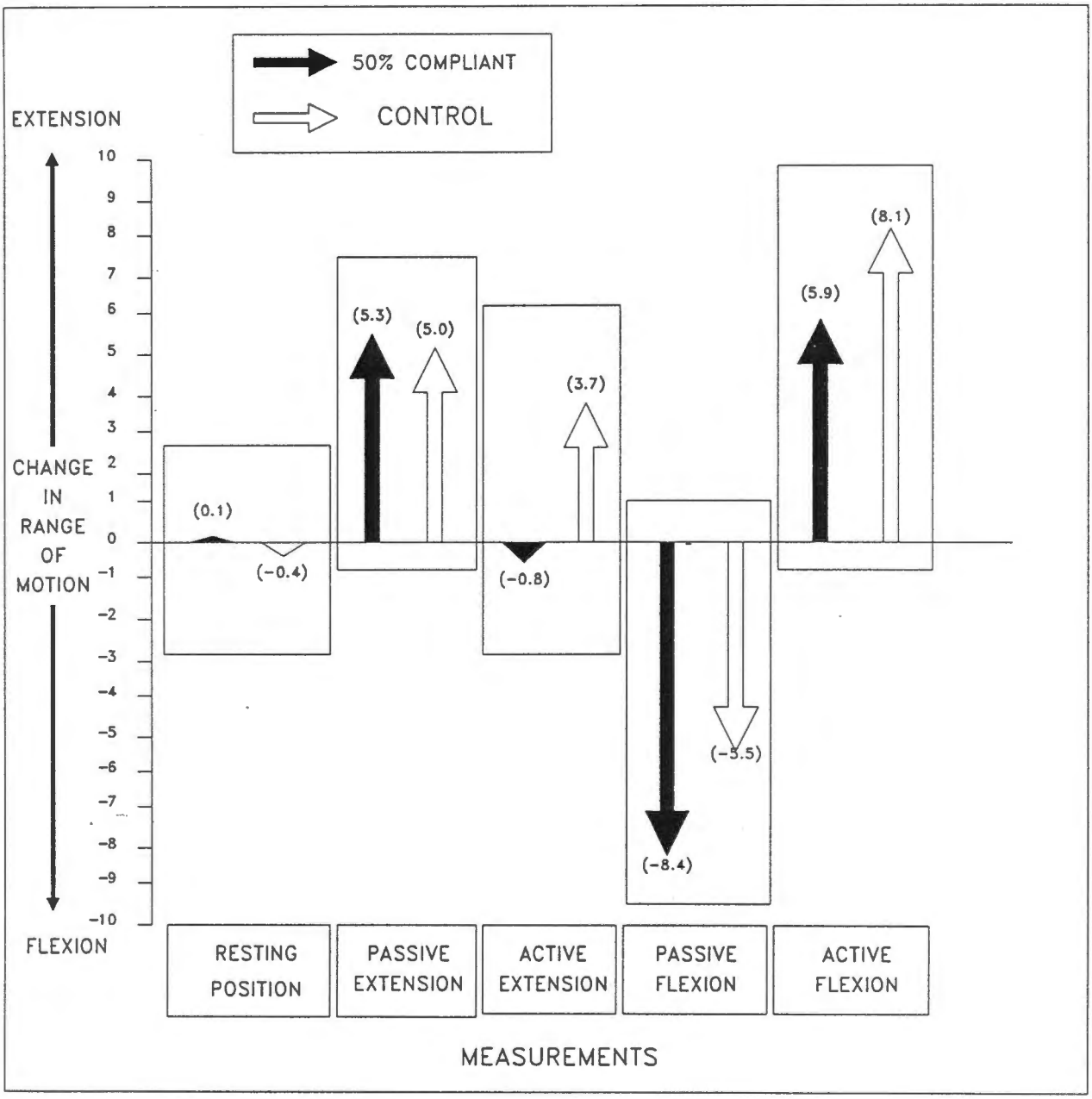
No significant differences were found (Table 33). The compliant patients, however, experienced a slight decrease in hyperextension whereas the swan neck control group experienced an increase. The compliant group achieved a greater increase in passive flexion and lost less active flexion than the swan neck control group (Graph 10).

TABLE 33: MEAN DIFFERENCE (SE) OF PIP JOINT RANGE OF SWAN NECK DEFORMITY: (LAST - FIRST) MEASUREMENT, ADJUSTED FOR THE FIRST MEASUREMENT USING COVARIANCE ANALYSIS (EXCLUDING NON-COMPLIANT PATIENTS FROM THE EXPERIMENTAL GROUP)

MEASUREMENTS	COMPLIANT EXPERIMENTAL	CONTROL	P-VALUE
RESTING POSITION	0.107 (1.996)	-0.412 (1.700)	0.847
PASSIVE EXTENSION	5.353 (2.051)	5.074 (1.752)	0.919
ACTIVE EXTENSION	-0.880 (1.903)	3.712 (1.682)	0.081
PASSIVE FLEXION	-8.406 (3.961)	-5.538 (3.508)	0.595
ACTIVE FLEXION	5.965 (5.313)	8.170 (4.706)	0.760

(SE)=STANDARD ERROR

GRAPH 10: CHANGES IN PIP JOINT RANGE (LAST – FIRST) MEASUREMENT FOR SWAN NECK DEFORMITIES: A COMPARISON BETWEEN COMPLIANT EXPERIMENTAL PATIENTS AND THE CONTROL GROUP



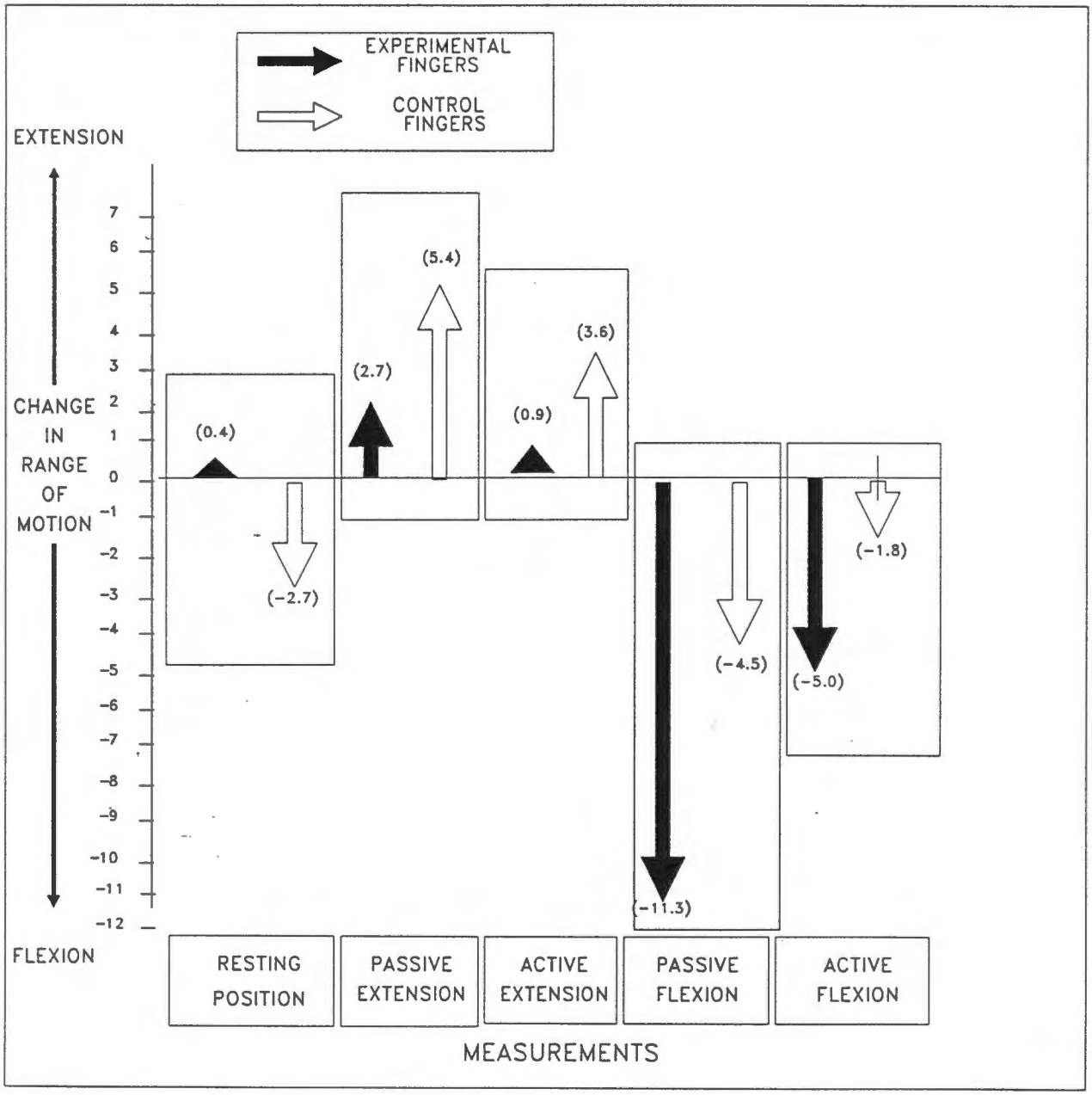
9.6 CHANGE IN PIP JOINT RANGE IN PATIENTS WITH BOTH EXPERIMENTAL AND CONTROL FINGERS:

For those patients from the experimental group that did have similar deformities in the opposite hand, a control finger of the same grade was chosen from that hand. Eleven such patients with swan neck deformities were found. A comparison of mean difference between first and last measurement of experimental finger and control finger obtained a significantly higher (p=0.044) increase in passive flexion in the swan neck experimental fingers than the control fingers (Table 34). Although not significantly so, the experimental fingers showed a smaller increase in both passive and active hyperextension than the control fingers; the experimental fingers had a larger increase in active flexion than the control fingers (Graph 11).

TABLE 34: MEAN DIFFERENCE (SE) OF PIP JOINT RANGE OF SWAN NECK DEFORMITY: (LAST - FIRST) MEASUREMENT, FOR PATIENTS WITH BOTH EXPERIMENTAL AND CONTROL FINGERS

MEASUREMENTS	EXPERIMENTAL FINGERS	CONTROL FINGERS	DIFFERENCE	P-VALUES
RESTING POSITION	0.455 (2.282)	-2.727 (2.967)	3.182 (3.521)	0.378
PASSIVE EXTENSION	2.273 (3.527)	5.455 (3.049)	-3.182 (5.571)	0.580
ACTIVE EXTENSION	0.909 (1.760)	3.636 (2.619)	-2.727 (2.727)	0.341
PASSIVE FLEXION	-11.364 (2.868)	-4.545 (2.817)	-6.818 (2.960)	0.044
ACTIVE FLEXION	-5.000 (3.754)	-1.818 (2.960)	-3.182 (3.322)	0.361

GRAPH 11: CHANGES IN PIP JOINT RANGE (LAST – FIRST) MEASUREMENT FOR SWAN NECK DEFORMITY: A COMPARISON BETWEEN EXPERIMENTAL AND CONTROL FINGERS IN THE SAME PATIENTS



10. RESULTS FOR BOUTONNIERE DEFORMITIES:

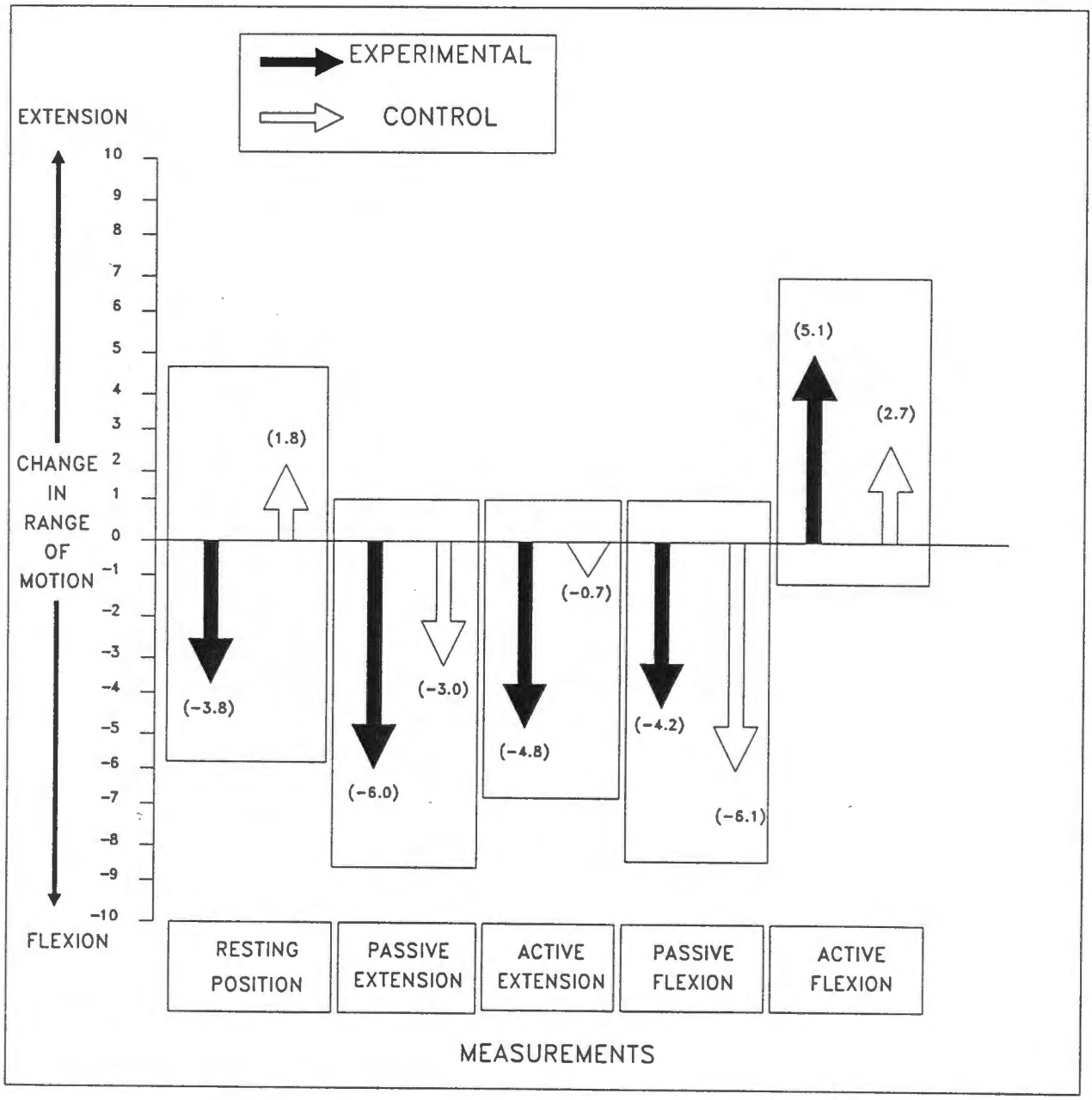
10.1 CHANGE IN JOINT RANGE OF PIP JOINTS:

10.1.1 No significant differences between the change in mean joint range of boutonniere experimental groups and boutonniere control groups were found (Table 35). The general pattern that emerged however was a larger decrease in both passive and active extention in the boutonniere experimental group than the boutonniere control group; a smaller increase in passive flexion and a larger decrease in active flexion in the boutonniere experimental group than the boutonniere control group (Graph 12).

TABLE 35: MEAN DIFFERENCE (SE) OF PIP JOINT RANGE OF BOUTONNIERE DEFORMITY: (LAST - FIRST) MEASUREMENT, ADJUSTED FOR THE FIRST MEASUREMENT USING COVARIANCE ANALYSIS

MEASUREMENTS	BOUTONNIERE EXPERIMENTAL	BOUTONNIERE CONTROL	P-VALUE
RESTING POSITION	-3.864 (2.960)	1.840 (2.614)	0.169
PASSIVE EXTENSION	-6.029 (2.621)	-3.030 (2.327)	0.400
ACTIVE EXTENSION	-4.843 (2.478)	-0.703 (2.200)	0.222
PASSIVE FLEXION	-4.259 (1.701)	-6.112 (1.510)	0.423
ACTIVE FLEXION	5.136 (1.705)	2.787 (1.514)	0.312

GRAPH 12: CHANGES IN PIP JOINT RANGE (LAST – FIRST) MEASUREMENT FOR BOUTONNIERE DEFORMITIES: A COMPARISON BETWEEN EXPERIMENTAL AND CONTROL GROUPS



10.1.2 The alternate approach analysing the difference in profile changes did not show any significant difference between the boutonniere experimental and boutonniere control groups for any of the measurement modalities (Table 36). This approach neccesitated the further loss of four patients who had less than four measurements.

TABLE 36: LONGITUDINAL DATA OF BOUTONNIERE DEFORMITY: COMPARING PROFILES OF CHANGES IN MEAN RANGE (SE) OF EXPERIMENTAL AND CONTROL GROUPS (N=30)

MEASUREMENT	1 MEAN (SE)	2 MEAN (SE)	3 MEAN (SE)	4 MEAN (SE)	P-VALUE
RESTING POSITION					
EXPERIMENTAL	33.08 (3.53)	30.77 (3.31)	24.62 (3.26)	26.54 (3.60)	0.1190
CONTROL	26.65 (3.09)	27.06 (2.90)	28.53 (2.85)	27.65 (3.15)	
PASSIVE EXTENSION					
EXPERIMENTAL	5.77 (3.50)	5.00 (4.10)	-0.38 (4.26)	-1.15 (4.14)	0.1149
CONTROL	8.71 (3.06)	4.12 (3.58)	5.29 (3.72)	5.59 (3.62)	
ACTIVE EXTENSION					
EXPERIMENTAL	16.77 (3.28)	17.69 (4.09)	16.92 (5.45)	12.31 (4.48)	0.2093
CONTROL	16.06 (2.87)	12.65 (3.58)	12.06 (4.77)	16.18 3.92)	
PASSIVE FLEXION					
EXPERIMENTAL	71.92 (3.59)	72.31 (3.13)	68.08 (3.34)	68.85 (3.11)	0.0749
CONTROL	74.71 (3.14)	68.53 (2.74)	70.59 (2.92)	67.94 (2.72)	
ACTIVE FLEXION					
EXPERIMENTAL	78.85 (3.45)	81.15 (3.60)	76.54 (3.14)	78.08 (3.41)	0.2531
CONTROL	80.29 (3.02)	77.65 (3.15)	78.82 (2.75)	75.59 (2.98)	

SE=STANDARD ERROR

FOR "RESTING POSITION" AND "EXTENSION" THE DATA ARE GIVEN AS THE DEVIATIONS FROM 180 DEGREES.

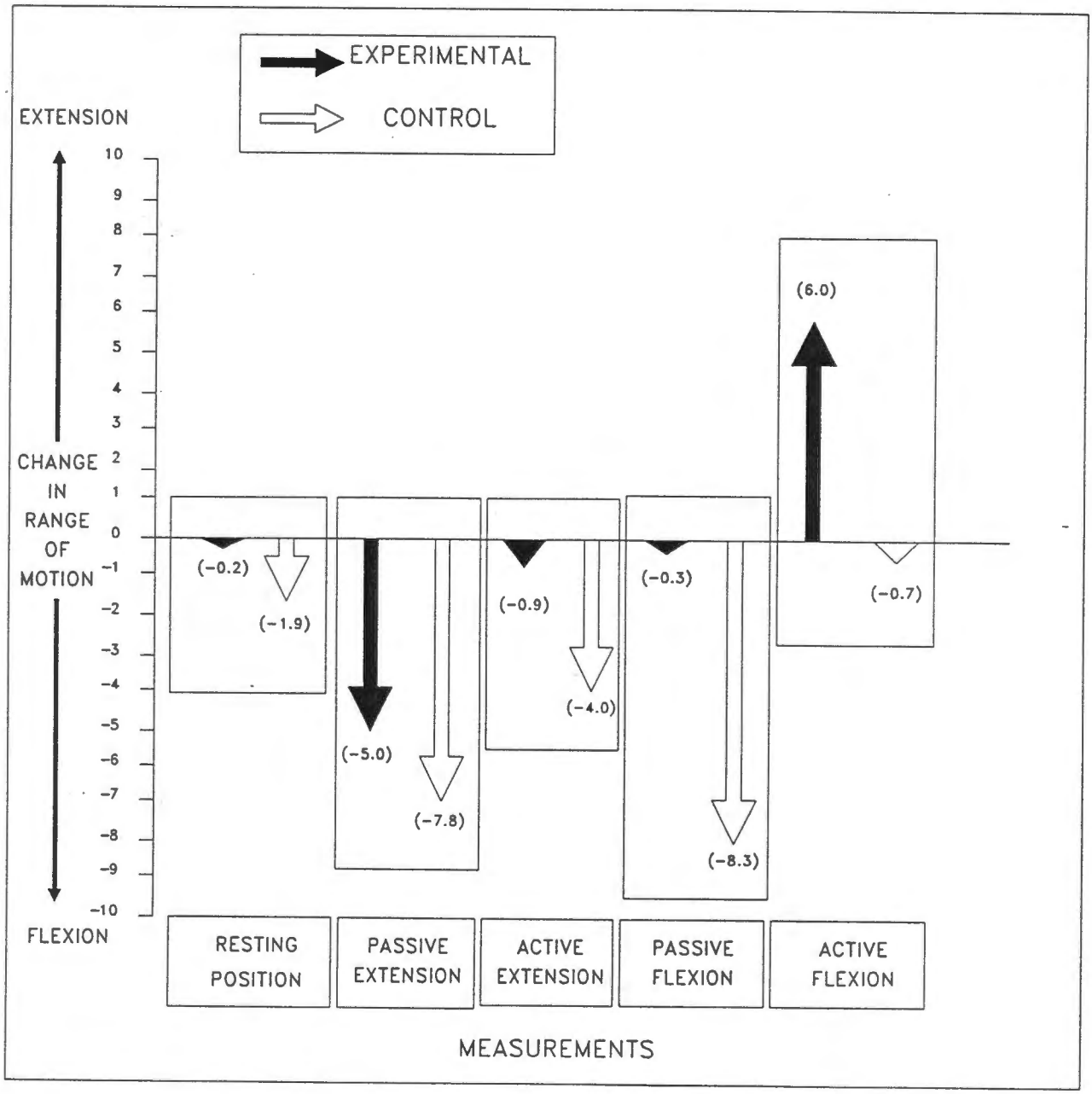
10.2 CHANGES IN PIP JOINT RANGE OF GRADE I DEFORMITY:

A significantly smaller (p=0.47) increase of passive flexion was achieved in the boutonniere grade I experimental group than the boutonniere grade I control group. A significantly larger decrease (p=0.021) in active flexion was found in the grade I experimental group than the grade I control group (Table 37). No significant difference between the groups for passive and active extension was achieved, but a tendency of a smaller decrease in passive and active extension in the boutonniere experimental group than the boutonniere control group exists (Graph 13).

TABLE 37: MEAN DIFFERENCE (SE) OF PIP JOINT RANGE OF GRADE I BOUTONNIERE DEFORMITY: (LAST - FIRST) MEASUREMENT USING COVARIANCE ANALYSIS

MEASUREMENTS	GRADE I EXPERIMENTAL	GRADE I CONTROL	P-VALUE
RESTING POSITION	-0.213 (4.629)	-1.990 (3.876)	0.781
PASSIVE EXTENSION	-5.016 (4.069)	-7.844 (3.437)	0.609
ACTIVE EXTENSION	-0.952 (3.361)	4.034 (2.832)	0.504
PASSIVE FLEXION	-0.335 (2.588)	-8.332 (2.164)	0.047
ACTIVE FLEXION	6.019 (1.812)	-0.728 (1.522)	0.021

GRAPH 13: CHANGES IN PIP JOINT RANGE (LAST – FIRST) MEASUREMENT FOR GRADE I BOUTONNIERE DEFORMITIES: A COMPARISON BETWEEN EXPERIMENTAL AND CONTROL GROUPS



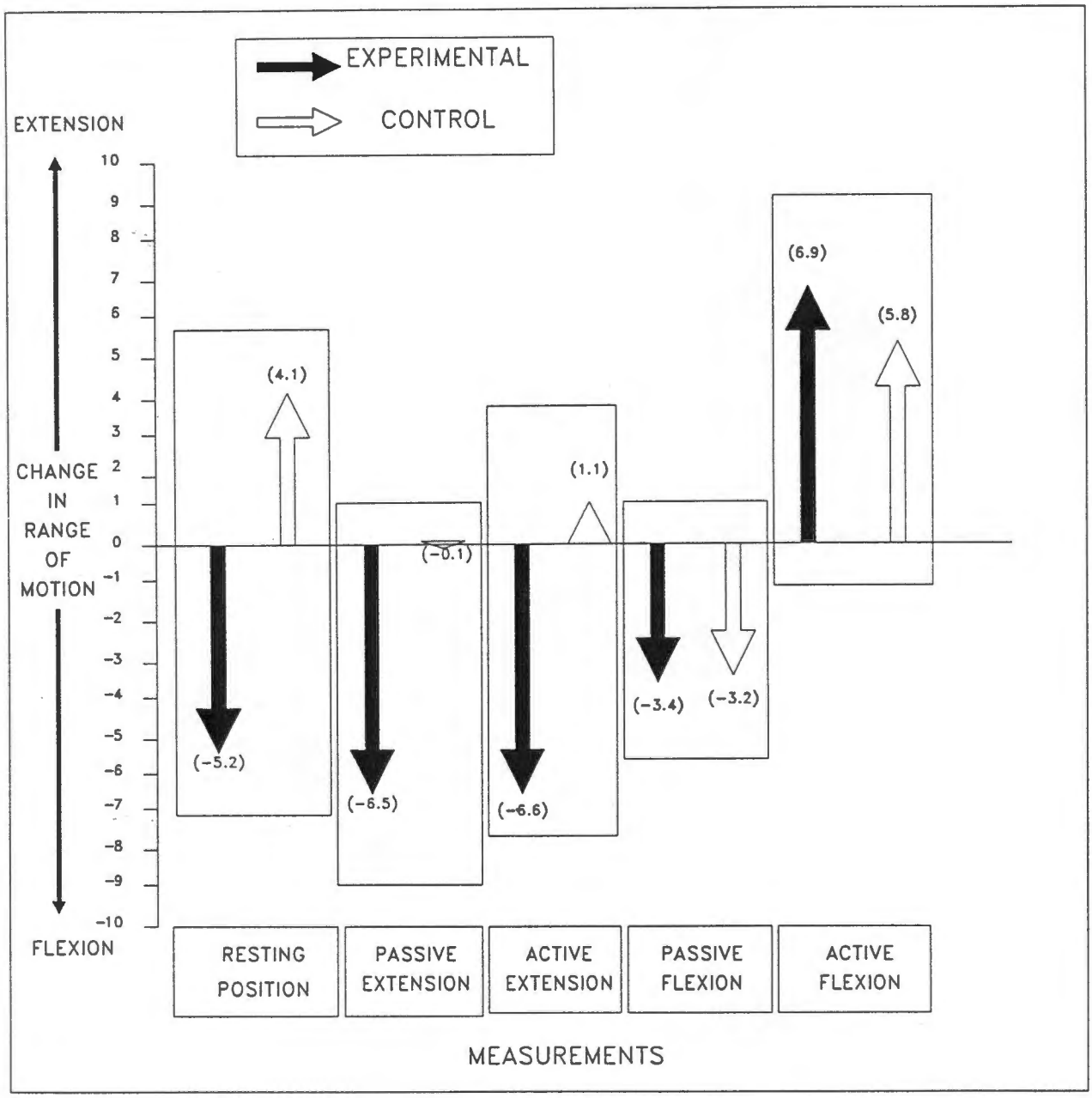
10.3 CHANGES IN PIP JOINT RANGE OF GRADE II DEFORMITY:

No significant differences between boutonniere grade II experimental group and boutonniere grade II control group were found (Table 38). The grade II experimental group's position of rest tended to change to a more flexed position and the grade II control group's to a less flexed position (p=0.077). A large decrease in passive and active extension in the grade II experimental group was found in contrast to a slight decrease in passive extension and an increase in active extension in the grade II control group (Graph 14).

TABLE 38: MEAN DIFFERENCE (SE) OF PIP JOINT RANGE OF BOUTONNIERE GRADE II DEFORMITY: (LAST - FIRST) MEASUREMENT, ADJUSTED FOR THE FIRST MEASUREMENT USING COVARIANCE ANALYSIS

MEASUREMENTS	GRADE II EXPERIMENTAL	GRADE II CONTROL	P-VALUE
RESTING POSITION	-5.221 (3.436)	4.109 (3.436)	0.077
PASSIVE EXTENSION	-6.567 (3.758)	-0.100 (3.758)	0.249
ACTIVE EXTENSION	-6.688 (3.523)	1.133 (3.523)	0.137
PASSIVE FLEXION	-3.428 (2.482)	-3.428 (2.482)	0.958
ACTIVE FLEXION	6.972 (2.510)	5.806 (2.510)	0.752

GRAPH 14: CHANGES IN PIP JOINT RANGE (LAST – FIRST) MEASUREMENT FOR GRADE II BOUTONNIERE DEFORMITIES: A COMPARISON BETWEEN EXPERIMENTAL AND CONTROL GROUPS



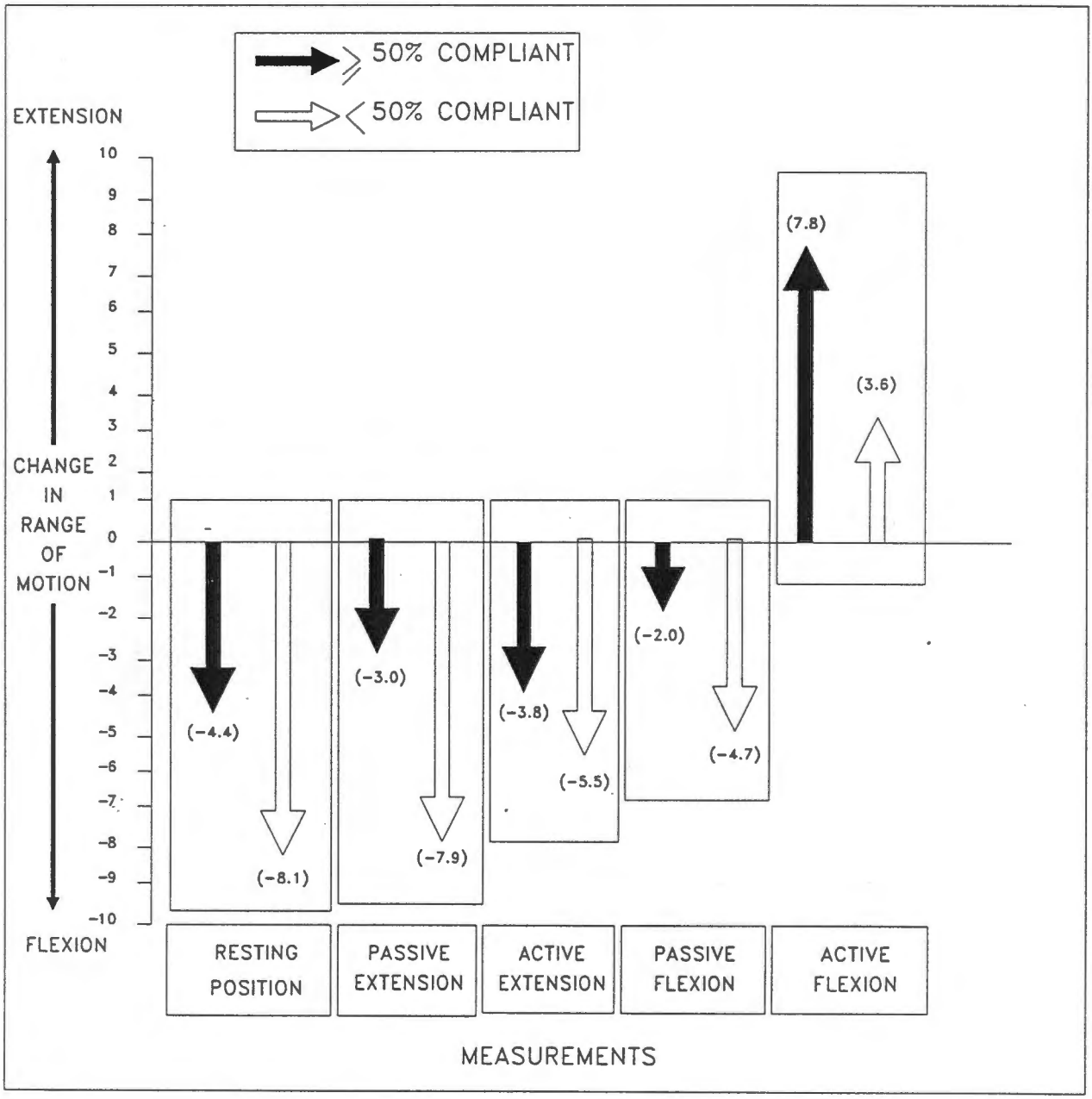
10.4 CHANGES IN PIP JOINT RANGE COMPARING COMPLIANT AND NON-COMPLIANT PATIENTS FROM THE EXPERIMENTAL GROUP

The same parameter of 50% compliance that was used for swan neck deformities was used here again. No significant differences between the compliant and non-compliant groups were found (Table 39). The compliant group, however, showed a smaller increase in the flexed resting position and a smaller decrease in passive and active extension. Furthermore, the compliant group revealed a smaller increase in passive flexion and a larger decrease in active flexion than the non-compliant group (Graph 15).

TABLE 39: MEAN DIFFERENCE (SE) OF PIP JOINT RANGE OF BOUTONNIERE DEFORMITY: (LAST - FIRST) MEASUREMENT, ADJUSTED FOR THE FIRST MEASUREMENT USING COVARIANCE ANALYSIS (A COMPARISON BETWEEN COMPLIANT AND NON-COMPLIANT PATIENTS FROM THE EXPERIMENTAL GROUP

	BOUTONNIERE EXPERIMENTAL		
MEASUREMENTS	COMPLIANT	NON-COMPLIANT	P-VALUE
RESTING POSITION	-4.499 (4.923)	-8.112 (3.987)	0.586
PASSIVE EXTENSION	-3.022 (3.508)	-7.985 (2.806)	0.313
ACTIVE EXTENSION	-3.882 (4.102)	-5.523 (2.424)	0.773
PASSIVE FLEXION	-2.034 (2.999)	-4.755 (2.424)	0.504
ACTIVE FLEXION	7.814 (2.971)	3.680 (2.385)	0.318

GRAPH 15: CHANGES IN PIP JOINT RANGE (LAST – FIRST) MEASUREMENT FOR BOUTONNIERE DEFORMITIES: A COMPARISON BETWEEN MORE THAN 50% COMPLIANT AND LESS THAN 50% COMPLIANT PATIENTS



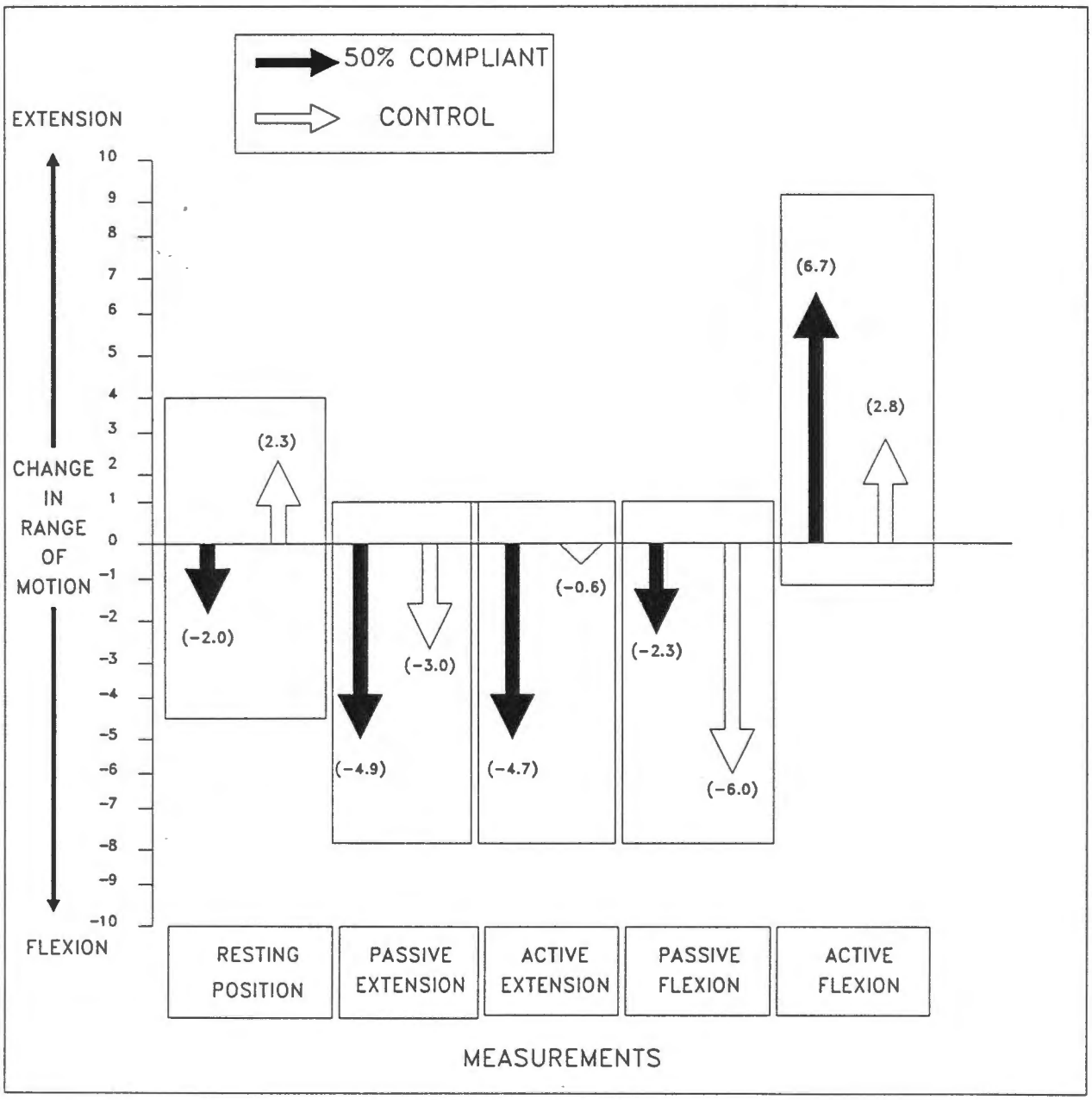
10.5 CHANGES IN PIP JOINT RANGE COMPARING ONLY THE COMPLIANT PATIENTS FROM THE EXPERIMENTAL GROUP WITH THE CONTROL GROUP

No significant differences between the compliant group and the boutonniere control group were found (Table 40). The compliant group showed an increased flexed resting position, whilst the boutonniere control group had a more extended resting position than at first. The compliant group showed a larger decrease in passive and active extension than the control group. The compliant group showed a smaller increase in passive flexion and a larger decrease in active flexion than the control group (Graph 16).

TABLE 40: MEAN DIFFERENCE (SE) OF PIP JOINT RANGE OF BOUTONNIERE DEFORMITY: (LAST - FIRST) MEASUREMENT, ADJUSTED FOR THE FIRST MEASUREMENT USING COVARIANCE ANALYSIS (A COMPARISON BETWEEN ONLY COMPLIANT PATIENTS FROM THE EXPERIMENTAL GROUP AND THE CONTROL GROUP

MEASUREMENTS	EXPERIMENTAL COMPLIANT	CONTROL	P-VALUE
RESTING POSITION	-2.051 (4.435)	2.332 (2.392)	0.406
PASSIVE EXTENSION	-4.999 (4.721)	-3.053 (2.645)	0.723
ACTIVE EXTENSION	-4.712 (4.283)	-0.670 (2.342)	0.425
PASSIVE FLEXION	-2.383 (2.728)	-6.090 (1.534)	0.252
ACTIVE FLEXION	6.770 (2.713)	2.862 (1.510)	0.224

GRAPH 16: CHANGES IN PIP JOINT RANGE (LAST – FIRST) MEASUREMENT FOR BOUTONNIERE DEFORMITIES: A COMPARISON BETWEEN COMPLIANT PATIENTS FROM THE EXPERIMENTAL GROUP AND CONTROLS



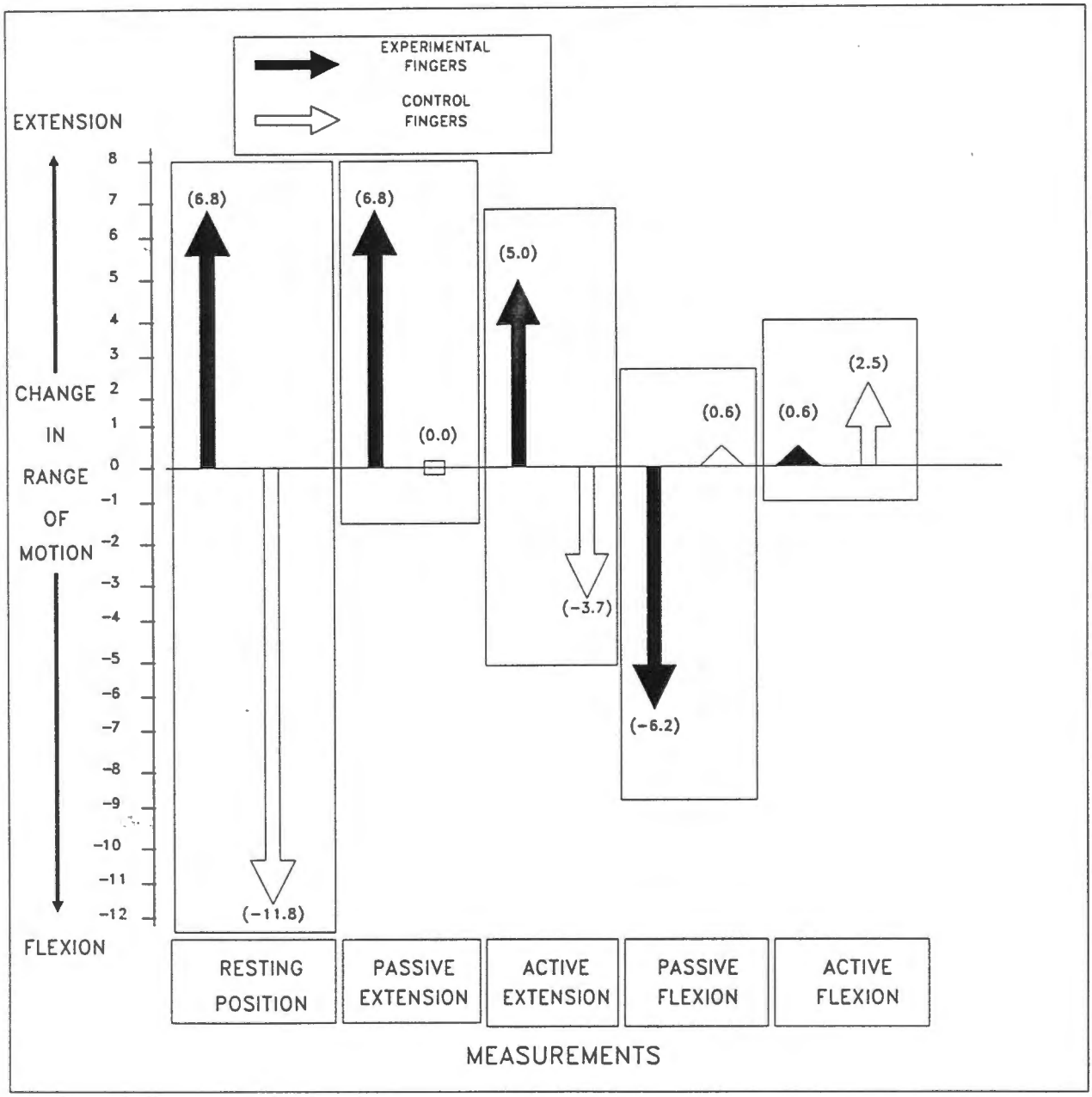
10.6 CHANGE IN PIP JOINT RANGE IN PATIENTS WITH BOTH EXPERIMENTAL AND CONTROL FINGERS:

As for the swan neck deformity, a control finger was chosen for those patients in the experimental group who had comparable boutonniere deformities in the other hand. Eight such patients were found. No significant dissimilarities were found in the mean difference (last - first measurement) between the experimental and control fingers (Table 41). The experimental finger had a marked increase in **extension** in the resting position compared to a considerable increase in **flexed** resting position in the control fingers (p=0.64) (Table 41). Passive extension and active extension of the experimental fingers were increased compared to a lack of change in passive extension and a decrease in active extension in the control fingers (Graph 17).

TABLE 41: MEAN DIFFERENCE (SE) OF PIP JOINT RANGE OF BOUTONNNIERE DEFORMITY: (LAST - FIRST) MEASUREMENT, FOR PATIENTS WITH BOTH EXPERIMENTAL AND CONTROL FINGERS

MEASUREMENTS	EXPERIMENTAL FINGERS	CONTROL FINGERS	DIFFERENCE	P-VALUE
RESTING POSITION	6.875 (6.046)	-11.875 (5.820)	18.750 (8.543)	0.064
PASSIVE EXTENSION	6.875 (3.652)	0.0 3.896)	6.875 (4.218)	0.147
ACTIVE EXTENSION	5.000 (3.780)	-3.750 (4.092)	8.750 (5.570)	0.160
PASSIVE FLEXION	-6.250 (3.098)	0.625 (5.782)	-6.875 (5.340)	0.239
ACTIVE FLEXION	0.625 (2.396)	2.500 (4.119)	-1.875 (2.825)	0.528

GRAPH 17: CHANGES IN PIP JOINT RANGE (LAST – FIRST) MEASUREMENT FOR BOUTONNIERE DEFORMITIES: A COMPARISON BETWEEN EXPERIMENTAL AND CONTROL FINGERS FROM THE SAME PATIENTS



11. RESULTS OF MEASUREMENT OF COMPLIANCE IN SPLINT WEARING:

Compliance of patients was measured by means of a short questionnaire (see Appendix 1). Questions were geared towards getting information on the estimated number of days the splint was worn as well as the hours per day and whether the patient had worn the splint mainly at night, mainly in the day time or a combination of the above.

TABLE 42: RESULTS OF COMPLIANCE QUESTIONNAIRE:

COMPLIANCE INDICATOR	SWAN NECK	BOUTONNIERE
% COMPLIANCE AFTER FIRST VISIT	71.3%	63%
MEAN % OF COMPLIANCE	59.3%	50.3%
% COMPLIANCE AFTER 1 YEAR	26%	32%
WORN 5 HOURS AND MORE PER 24 HOURS	63%	67.2%
WORN ONLY AT NIGHT	43%	58%
WORN ONLY IN DAY	33.8%	16.3%

For statistical purposes it was necessary to find an uncomplicated method by which to categorise the study sample into "compliant" and "non-compliant" patients. A patient was described as being "compliant" when (s)he had worn the splint for an average of 50% or more of the total number of days the splint was prescribed for.

The mean compliance of patients who received splints for swan neck deformity was 59.3%. Their mean compliance dropped from 71.3% after the first visit to 26% a year later. The splint for swan neck deformity was

worn at night by some and during the day-time by others and 63% wore it for five hours and more per 24 hour period. The compliance of patients who received a splint for boutonniere deformity was 50.3%. Their mean compliance decreased from 63% to 32% after one year. This splint was worn mainly at night and 67.2% of patients wore it for five hours or more per day.

SUMMARY:

1. The "range of movement" pilot study revealed a weak test-retest reliability for the measurement of flexion of the PIP joint. The inter-rater reliability of flexion was likewise weaker than that for extension, implying measurement variation inherent to measurement of flexion. Biological variation was found to be reasonably small (i.e an interval of 7.2 degrees at most).

2. In the "strain on hands" pilot study it was found that the instrument which had been developed was sensitive enough to discriminate between the amount of strain experienced by normal people compared with the strain that arthritics placed on their hands.

3. The swan neck deformity results seemed to indicate more positive results for the experimental group than the control group, if the composite picture of development of the deformity was taken into account. The only significant part of these results was a smaller increase in active hyperextension in the experimental group. The swan neck experimental and control groups were fairly even in terms of most confounding variables, except for "clinic attended" and "grade of deformity". The swan neck experimental group consisted of more patients from the Thursday clinic

than the Tuesday clinic and more patients with grade I than grade II deformities.

The general tendencies which had been evident, did not change when they were was tested for the influence of "grade of deformity". The factor "compliance" reversed the direction of the outcome in an unexpected direction. Non-compliant patients achieved more positive results than compliant patients. When compliant patients were compared to the control group, the tendencies were reversed to the original positive outcome for splint wearing. Patients who received splints for swan neck deformity had a compliance of 71.3% after the first visit, which dropped to 26% after one year.

A different perspective was gained when experimental and control fingers of the same patients in the experimental group were compared. This group consisted mainly (77%) of patients from the Thursday clinic. This analysis yielded significantly larger gains in passive flexion for the experimental fingers. Furthermore both experimental and control fingers gained active flexion in contrast to the persistent loss of active flexion by both the overall experimental and control groups.

4. The overall results of the boutonniere experimental group indicated a larger loss of both extension and flexion in the experimental group than the control group. None of these results were significant. The boutonniere experimental and control groups differed not more than 9.8% in terms of most confounding factors. However the boutonniere control group consisted of more patients from the Tuesday than the Thursday clinic as well as more patients with grade I than grade II deformities.

The boutonniere grade I control group gained significantly more passive flexion than the grade I experimental group. Furthermore, the grade I control group lost significantly less active flexion than the experimental group. These differences were not seen in the results of grade II deformities.

The generally more negative results of the experimental group that had been evident, were changed to be slightly more favourable for the compliant patients than the non-compliant patients, but not significantly so. This tendency was changed back to its old direction, when compliant patients from the experimental group were compared to the control group.

When fingers with boutonniere deformities which had been splinted were compared with control fingers from the same patient, the results for the splinted fingers were less negative than was the case with the overall results of the boutonniere experimental group.

5. Both experimental and control groups with swan neck or boutonniere deformity lost active flexion, with one exception. Both the experimental and control fingers from the swan neck experimental patients, of whom both an experimental and control finger was chosen for analysis, gained active flexion.

CHAPTER IV

INTRODUCTION

Results which were presented in Chapter III will be discussed separately for swan neck and boutonniere deformities. The discussion will centre around possible explanations for the direction of the significant results as well as the non-significant but apparent tendencies. The possible influence of bias pertaining to sampling and measurement will be discussed subsequently. Possible solutions to or implications of findings will be discussed in Chapter V.

1. SWAN NECK DEFORMITY EXPERIMENT

1.1 COMPOSITE PICTURE OF SUCCESSFUL PREVENTION OF DETERIORATION OF SWAN NECK DEFORMITIES:

Successful prevention of worsening of swan neck deformities could manifest itself in terms of different modalities of active and passive range of movement (ROM), but could also be reflected in a composite picture of combinations of ROM modalities.

Resting in a less extended position and achievement of less passive hyperextension accompanied by less active hyperextension could mean that the palmar soft tissue has shortened. This may include healing of strained ligaments. If, however, a decrease in active hyperextension is not accompanied by a decrease in passive hyperextension, this may illustrate a

loss of extensor muscle strength (Smith, 1978) and is therefore a negative sign with regards to prevention of deformity (Patla, 1989)

An increase in passive and active flexion may imply that the dorsal soft tissues are supple enough to allow more flexion. These gains may include a slight stretch of the extensor tendon and the extensor expansion as well as a release on the strong pull on the middle slip of the extensor by the intrinsic muscles (Chapter II, p.23). An increase of passive flexion could also mean rupture of extensor tendons, but this is usually found with boutonniere deformities rather than swan neck deformities (Chapter II, p.32). A decrease of active flexion with an increase in passive flexion could simply imply the loss of flexion muscle strength (Smith, 1978).

1.2 OVERALL RESULTS OF SWAN NECK SPLINTING:

Only one significant difference between the experimental and control groups was found, but tendencies of difference in composite pictures, especially if they were consistent, could give valuable indications of the results which could have been obtained if a large enough sample was used.

The only significant difference between the experimental and control groups was the larger decrease in active hyperextension experienced by the swan neck experimental group. This, combined with the tendency (not significant) of a larger decrease of passive hyperextension as well as a larger increase of active flexion (not significant) by the swan neck experimental group indicate a shortening of palmar structures along with more supple dorsal structures.

Both the swan neck experimental and swan neck control groups lost active flexion; the control group more so than the experimental group. A general

deterioration in muscle strength, unrelated to splint wearing, seems to be evident. The experimental group was however slightly better off than the control group. This could be explained by virtue of the better balanced soft tissue position in which the experimental group seemed to be, compared to the control group. In the control group active flexion during the performing of normal activities would be inhibited more than in the experimental group. The enhanced pull of the middle slip of the extensor expansion, which was counteracted in the experimental group by the splint, would prevent proper function of the flexors of the control group. The control group would therefore lose muscle power, mainly because the muscles could never contract to their fullest ability to move the joint through its full range.

The apparent loss of muscle strength could also have been influenced by the relatively weak test-retest reliability scores of active and passive flexion. This type of influence would be equally evident in both experimental and control groups as an increase in variability, rather than a consistent tendency in one direction. The pattern of loss of muscle strength was too consistent to be attributed to variation only.

1.3 DIFFERENCE OF GRADE I AND GRADE II DEFORMITIES

When separating the grade I and grade II swan neck deformity groups, one should be able to distinguish whether the grade of deformity had an influence on the results. It is for instance possible that the grade II deformity could be less subject to positive change once the joint is on the path of destruction.

Grade I and grade II deformity results yielded the same tendency with regards to a decrease in hyperextended position of rest as well as a

decrease in active extension. Small differences between the grades of deformity in terms of active and passive flexion did exist.

None of these results in which the experimental and control groups were compared proved significant, partly because separating the two grades of deformity left a smaller sample in each group.

1.4 RESULTS OF GRADE I DEFORMITIES:

The experimental group showed the pattern of a less extended resting position and a larger decrease in passive hyperextension, supporting the theory of shortening of palmar structures. Active extension of the experimental group was also less than active extension of the control group.

At the same time, active flexion of the experimental group was decreased compared to the small increase of active flexion of the control group. It would seem that for the grade I deformities the loss of muscle power was worse for the experimental group than the control group, although not significantly so.

1.5 RESULTS OF GRADE II DEFORMITIES:

The same general pattern indicating a shortening of palmar structures persisted with grade II swan neck deformities, although none of the differences were significant. In contrast to grade I deformities, the tendency of decrease in active flexion persisted for both experimental and control groups. This again means a general loss of flexor muscle strength. There seemed to be more to this loss of muscle strength than meets the eye.

It could be possible that the rate of loss of muscle strength is smaller for grade I deformities, as was illustrated by the almost unchanged range of active flexion of the grade I control group, while the effects the greater deforming forces have on the grade II deformity cause a more rapid deterioration in muscle strength, as seen in the results of grade II control group. The relative effect the splint has on these different situations should be considered carefully. In the grade I deformity, the splint seemed to cause a loss of muscle strength, while in the grade II deformity it seemed to guard against the forces causing this loss.

In the case of grade I swan neck deformities, muscle strength could be lost whilst wearing the splint because the hand might feel clumsy wearing the splint and subsequently the other hand has been used instead. Otherwise the splint may restrict movement to such an extent that muscles are not used optimally to their fullest range and strength.

In the case of grade II deformities, there seems to be a stage in the development of the deformity, where the splint does no harm, but protects the flexors of the fingers from possibly deteriorating more rapidly. This rapid loss of muscle strength in the grade II deformity may come about because of stretch and strain on the flexors at the hyperextended PIP joint. Secondly, it is also possible that the awkward 'snapping' of the PIP joint in an attempt to flex the fingers, causes the patient to avoid using the finger, which in turn causes more rapid atrophy.

1.6 THE INFLUENCE OF COMPLIANCE ON RESULTS OF SWAN NECK DEFORMITY SPLINTING

When the results of patients in the compliant and non-compliant groups within the experimental group were compared, a totally reversed pattern emerged. In a further analysis only the compliant patients from the experimental group were compared with the control group. No significant differences were found, but the general tendencies were reversed to the tendencies found in the overall results. The only explanation for this pattern of change is a large variability of the measurement due to the many possible influences on it.

One would presume that more significant results should have been achieved when the non-compliant patients were left out from the experimental group, because non-compliance diminishes the difference between the treatments the two groups received. However, in leaving out the non-compliant group of patients, the experimental group numbers were reduced and it became more difficult to obtain statistically significant results. If only these results were considered, it is impossible to state that compliance influenced results.

If the poor compliance results are considered, a number of questions arise:

If the patients do not wish to wear the splint, are the short-term benefits in terms of less strain on the joint of the splint not apparent to them? Do they perhaps become aware of stiffening of joints or loss of muscle power from the time that they start to wear the splint? Does the splint hamper them in performing daily activities? Alternatively, is it possible that patients with RA will inevitably rebel against another intervention in their already abnormal lifestyle?

1.7 A COMPARISON OF RESULTS OF AN EXPERIMENTAL FINGER AND A CONTROL FINGER OF THE SAME PATIENT:

A small sample of 11 patients, in respect of whom both an experimental and control finger could be found, were available. Analysing the difference between the experimental and control fingers, one does away with a multitude of variables pertaining to the person which could have influenced the results. The only variable which still could have an influence in this case is that of dominance on the rate of deterioration of the deformity. This sample was nevertheless virtually equal in terms of the number of dominant and non-dominant fingers that were splinted. The sample also consisted of equal numbers of patients with grade I and grade II deformities.

In spite of the small sample, a significantly greater increase in passive flexion ($p=0.44$) was achieved in the experimental fingers than the control fingers. The overall results as described above, in terms of resting position and active and passive extension, were confirmed by the results in this small sub-sample. In spite of the lack of significant results for the resting position and active and passive extension, all the evidence points in the direction of a positive outcome in terms of a halting of the increase in hyperextension.

A digression from the general trends in terms of active flexion was found in this subsample of eleven patients. Both the experimental fingers and the control fingers experienced an increase in active flexion. The experimental fingers had a larger increase than the control fingers. Keeping in mind that the test-retest reliability of measurement of active flexion was only in the region of $r=0.486$, one should not attribute any

special meaning to these results. If however these results are true, the question arises: Do the activity patterns that the patient involves the dominant hand and non-dominant hand in because of necessity prevent the rapid deterioration of muscle strength that was evident in most of the results?

As was discussed earlier, one possible reason for the general decrease in active flexion whilst the passive flexion increased, is loss of muscle strength because the functions of the hand with the deformity are taken over to an extent by the alternate hand for daily activities. This subsample of eleven patients consisted of all the patients randomly allocated to the experimental group that had a similar deformity in the other hand. It is reasonable to assume that these patients had bilaterally equal involvement and the experimental patients not included in these groups were those that either had no involvement in the other hand or deformities of a lesser or greater grade of deformity. If these three categories were of equal number, it would have meant that two thirds of the control sample had either no involvement or lesser involvement of the alternate hand. This would imply that two thirds of the sample could have had one undeformed hand which could easily take over the duties of the deformed hand, compared to the sample of patients who had equal involvement bilaterally. This theory of loss of muscle strength could explain this difference in results in the general sample and the small subsample. The patients whose hands were equally affected had to make do with both hands as well as they could, while the others used the other less deformed hand. Whether the increase of muscle strength is indeed an increase or just a lack of decrease is still debatable if considering the fairly weak test-retest reliability.

1.8 POSSIBLE BIASES IN MEASUREMENT:

1.8.1 The very weak test-retest reliability for passive flexion (r=0.02) and fairly weak test-retest reliability for active flexion (r=0.486) could have influenced the results in the sense that differences were due to measurement error and not to real change. The test-retest reliability for extension was however strong (r=0.894) The reasons for the low reproducibility of flexion scores compared to extension scores could be: the fingers when flexed at both the PIP DIP and MP joints, caused long fingernails to cut into the palm, and prevented total flexion; the extensor tendon was stretched over three joints when the MP joint was kept in flexion with the PIP joint while measuring, as in making a fist.

A different amount of manual force on the joint at different times might produce slightly more or less passive joint range; unequal effort by the patient could produce different active ranges of motion. However, the same reasoning should also apply to the extension measurement, where the reliability score was quite high. It is therefore reasonable to assume that variation was not mainly due to the force that the therapist put on the joint or the effort of the patient, but rather one of the other reasons named above.

Another contributing factor could be that the first measurements on the pilot sample were done when the researcher had had very little practice using the goniometer. These measurements were taken at the onset of the study period. After a while it became apparent that it was necessary to lubricate the joint of the goniometer. It is quite possible that the larger ranges of movement obtained at the second measurement six months later could be attributed to this. Secondly the variation could also be attributed

to the lack of experience using the ENRAF goniometer in ensuring that the arms of the goniometer were positioned correctly along the phalanges with the first measurements.

1.8.2 Interrater reliability follows the same pattern as test-retest reliability in that strong correlations were achieved for the extension measurements ($r=0.74$ and $r=0.831$) whereas the flexion measurements had relatively weak reliability correlations ($r=0.414$ and 0.374) The second rater reasonably consistently achieved a larger range of movement than the first rater. The fact that the flexion measurements again did not correlate as well, points to the assumption that the discrepancy arises from the difference between the way flexion and extension is measured. Again the most important factors seem to be those of the position of the MP joint and the blocking of movement by the fingernails in the palm.

1.8.3 Biological variation between people should not have had a profound influence on the results because the mean differences were compared and not the differences between the means of the groups. The first measurement of a patient was subtracted from the last measurement, to obtain differences. These differences were then averaged for the experimental and control groups. Because analysis was done on the differences (i.e. improvement or deterioration) of the person, biological variation was ruled out as a confounding variable.

1.9 POSSIBLE BIASES IN SAMPLING:

1.9.1 More of the patients included in the swan neck sample came from the Thursday clinic. Traditionally the Thursday clinic was run for white patients and the Tuesday clinic for coloured and black patients. The Thursday clinic should theoretically incorporate patients of a higher socio-economical status than the Tuesday clinic. However, many deviations from this distinction exist and the exact socio-economic status of the patients which were included in the sample was not established. If indeed there was a difference between the two clinics in terms of socio-economic status, one would assume that the difference would be in terms of the more manual types of activities patients in the lower income groups would have to perform, which could have had a detrimental effect on the development of deformities on the one hand and conversely, could possibly force the patient to maintain muscle strength. It was reported (see Chapter II, p.17), that lower socioeconomic groups had poorer prognoses, but it was not stated whether this general description of prognosis coincided with prognosis for the development of deformity.

The only difference in the allocation of patients from either clinic to experimental and control groups was that the experimental group had four more patients from the Thursday clinic than the control group. It was established that the amount of strain the experimental and control groups placed on their joints did not differ significantly, so the theory that Thursday patients, and subsequently the experimental group, had a better prognosis in terms of strain on the joints of the hands, was not feasible. It was still possible that the Thursday patients (and the experimental group) were in a position to avoid manual activities to the detriment of their muscle strength. It was however found that the experimental patients

lost less muscle strength than the control groups. Bias on grounds of muscle strength loss because of better socio-economic status could therefore also be discarded.

One can safely assume that the imbalance of patients with swan neck deformities from the two clinics did not bias the results.

1.9.2 More patients with grade I than grade II swan neck deformity were eventually left in the experimental group. For this reason the effect of grades of deformities were tested (see 1.3 to 1.5). Indeed, a slightly different pattern for grade I and grade II swan neck deformity was established. This difference was in terms of active and passive flexion. The grade I deformities had a worse outcome in this respect, and seeing that more grade I deformities than grade II deformities were included in the experimental group, the results of the experimental group should have been adversely affected.

1.9.3 One of the important factors which could influence the development of deformities, is possibly the amount of strain put on the hand joints by the activities performed by the person. The total strain scores of patients in the experimental and control groups did not differ significantly ($p=0.25$). This influence can thus be ignored.

1.9.4 The experimental and control groups were equal in the number of dominant hands included in the study as well as the age of the patients.

2. BOUTONNIERE DEFORMITY EXPERIMENT:

2.1 COMPOSITE PICTURE OF SUCCESSFUL PREVENTION OF DETERIORATION IN BOUTONNIERE DEFORMITY:

The main manifestation of success in halting the development of a boutonniere deformity is a lack of decrease of the extension range of motion. Both passive and active range of extension is important. Gaining of passive range, implies the stretching of taut lateral bands and possibly the Landsmeer ligament (Chapter II, p.35). Gaining of active extension range may mean a slackening of the taut soft tissue to a stage where the extensors can overcome the flexion force exerted by the lateral bands as well as the Landsmeer ligament.

If passive range shows an increase but active range lags behind, the extensor muscles may be losing strength or, more likely, the mechanical force against which the extensor must operate is too large by virtue of tight ligaments. An increase in passive flexion range, coupled with a decrease of extension range, may indicate further damage to the insertion of the middle slip of the extensor expansion at the base of the second phalanx (Chapter II, p.33).

PIP flexion range of motion should not be primarily impaired by a true boutonniere deformity (Chapter II,p.35). Both active and passive flexion could be lost because of stiffening of the joint as the result of effusion or simply because the joint is never taken through its fullest range of movement.

2.2 OVERALL RESULTS OF BOUTONNIERE DEFORMITY:

Overall results comparing the experimental group with the control group yielded no significant differences. The trend however was for the experimental group to lose more extension, both actively and passively, than the control group. This would imply that the patients wearing the splint were worse off than the ones that were left alone. Whether other variables influenced the results or whether the splint caused actual harm, remains to be seen. (see Chapter V). The more positive results obtained by the experimental fingers, compared to the control fingers, lead the researcher to suspect the large variability of having a major influence on these results.

The smaller increase in passive flexion, combined with the larger decrease in active flexion of the experimental group appears to indicate a stiffening of the PIP joint plus loss of muscle strength in comparison to the control group. It is possible that the wearing of the splint could have had three devastating effects on the boutonniere deformity. Firstly the joint had stiffened, which was indicated by the loss of flexion; secondly the splint was ineffectual in preventing the deformity, indicated by no improvement in passive or active extension; and thirdly, the splint could at the same time have led to loss of extensor muscle strength, indicated by loss of active extension, because it was not a truly dynamic splint.

2.3 DIFFERENCES IN GRADE I AND GRADE II BOUTONNIERE DEFORMITY RESULTS

It is necessary to establish whether grade I and grade II boutonniere deformities was affected in the same way by splinting. The larger number of grade I deformities included in the experimental group could have

influenced the overall pattern described above, if a difference in the results of the two grades of deformities existed.

2.4 RESULTS OF BOUTONNIERE GRADE I DEFORMITIES:

The same tendency of a smaller increase in passive flexion by the experimental group was seen when only grade I deformities were included in the analysis. However, for grade I deformities this difference is significant (p=0.047)! Even more telling was the significantly larger decrease in active flexion (p=0.021) experienced by the experimental group. As more grade I deformities were included in the experimental group, it would seem that the negative effects the splinting programme seemed to have had on the grade I deformities made the overall results more negative.

2.5 RESULTS OF BOUTONNIERE GRADE II DEFORMITIES:

The same tendencies that were significant for boutonniere grade I and the overall picture, still persisted for grade II deformities, though not significantly so. The experimental boutonniere grade II deformities rested in a more flexed position than the control group (p=0.07), which also points to a deterioration in the group that received splints. It can be assumed that the influence of the larger number of grade I deformities in the overall sample did not have a major effect on the overall results.

2.6 THE INFLUENCE OF COMPLIANCE ON THE RESULTS OF BOUTONNIERE DEFORMITIES:

In order to determine whether indeed the splint was harmful, it would be useful to look at the influence that compliance in wearing of the splint had on the results.

Firstly the compliant patients and the non-compliant patients from the experimental group were compared. Secondly the control group was compared to only the compliant patients from the experimental group. In the first instance the compliant patients were slightly better off than the non-compliant patients, which is a reversal of the overall results. In the second analysis the general trend of the overall results was re-established, although slightly less negative to the experimental group. As was the case with the swan neck deformity, this lack of direction of the results could be attributed to the large variance in the measurement. Although none of the differences was significant, like the overall results, it must be kept in mind that dropping the non-compliant patients from the experimental group decreased the sample size and likewise the probability of finding significant results.

There is still a possibility that variables other than the splint could have influenced the prognosis for the development of deformities.

2.7 THE RESULTS OF A COMPARISON BETWEEN EXPERIMENTAL AND CONTROL FINGERS IN THE SAME PATIENT

A small sample of eight patients from the experimental group had comparable deformities on the alternate hand. It was thought that this comparison whould enable the researcher to do away with the influence of variables that particularly pertained to the physical and physiological differences between people. The only variable not excluded by this method was the influence of dominance on the results.

In six of the eight patients the splint was worn on the non-dominant hand. If dominant hands suffered more severe deformities than non-dominant hands, as was postulated earlier (Chapter II, p.38), the control fingers should have been more adversely affected than the experimental fingers.

Six of the patients had a grade II deformity on both hands. Earlier it was established that boutonniere grade II deformities achieved less devastating results than grade I deformities. The larger grade II component in this sample could have led to the more positive results of the experimental fingers.

Because of the small sample size, it was not unexpected that no significant differences would be found. The tendencies, however, were quite different from those discussed so far. The experimental group showed an increase in extension resting position compared to the increase in flexion in the resting position of the control group ($p=0.064$). Passive and active extension of the experimental group increased, compared to either the lack of change or the decrease of the control group's extension ($p=0.147$; $p=0.16$). These results clearly indicates positive outcomes, compared to the negative results obtained when looking at the overall experimental and control groups. One would presume that the combined effect of a larger contingent of grade II deformities as well as the larger number of dominant hands in the control finger group, had a positive influence on the results.

Unfortunately this sample is very small and real dangers of other types of bias do exist (see 2.8 and 2.9).

2.8 POSSIBLE BIASES IN MEASUREMENT:

2.8.1 Prevention of loss of PIP extension implies, more than any other modality of range of movement, a prevention of deterioration of boutonniere deformities. Test-retest reliability scores for active extension were high (r=0.894), and should therefore not contribute much to the variability of joint range measurements.

Test-retest reliability was very weak for passive flexion (r=0.02) and fairly weak for active flexion (r=0.486). One should therefore view the results of differences in passive flexion with caution. If, as discussed earlier in this chapter (see 1.8.1), the weak results were caused by procedural problems resulting in the first measurement being of smaller range than the second, these results should not have been unduly influenced by measurement bias of this nature, because those problems were solved during the pilot study, before commencement of the study itself.

2.8.2 Interrater reliability for boutonniere deformity should have the same negligible effect on the results as was discussed for swan neck deformities (see 1.8.2). The same would apply to the influence of biological variation between people (see 1.8.3).

2.9 POSSIBLE BIASES IN SAMPLING:

2.9.1 It was noted that the prevalence of boutonniere deformities in the Tuesday clinic seemed to be much higher than in the Thursday clinic (ratio of 2.1:1). This was also reflected in the eventual sample that was left after patients were lost from follow up (A ratio of 2.4:1) The results could have been influenced by other factors than the splinting program if such variables that differed for the two clinics existed.

If it is assumed that people with a low socio-economic status have a worse prognosis than richer people, it can be argued that the large proportion of patients from the Tuesday clinic should have influenced the prognosis for prevention of deterioration of deformities in the sample adversely. Because of this , and the fact that Tygerberg Hospital is a tertiary care facility which often excludes the milder cases, one can safely assume that the sample included people with a worse prognosis than would normally prevail in the community.

Another argument is that the lower socio-economic groups would not lose their muscle strength as rapidly as those patients who could afford to stop working or hire someone to do daily chores. If this is accepted, the loss of muscle strength in this sample may have produced an underrated estimation loss of muscle strength in the arthritic population.

If however the difference between experimental and control groups is considered, it is more important to look at the allocation of patients from the clinics to the two groups. The eventual allocation of patients from the Tuesday clinic to the experimental and control groups was even, but very few patients from the Thursday clinic were included in the experimental group. This could have had the possible result that the experimental group had a worse prognosis in terms of deterioration of the joint, but a better prognosis in terms of loss of muscle power. This was not the pattern that emerged, as both the joint mobility as well as the muscle strength of the experimental group were worse effected than the control group. The influence of the socio-economic factor was thus possibly not marked.

2.9.2 More patients with grade I boutonniere deformity were eventually included in the control group than the experimental group. When the difference in results of grade I and grade II boutonniere deformity was considered, the same tendency in terms of negative results was the outcome, but the grade I deformity had some significant differences which were not significant for grade II deformities. The larger number of grade I patients in the control group could therefore not have swung the results totally in the negative direction.

2.9.3 The male:female ratio of the experimental and control groups did not differ much, excluding sex as a confounding variable.

2.9.4 The experimental group had more dominant hands included than the control group. If the dominant hands had indeed a poorer prognosis (Chapter II, p.38) than the non-dominant hand, this could explain the poor results of the experimental group.

2.9.5 What influence the relatively low age of the patients suffering from boutonniere deformities could have had on results is difficult to ascertain. Certainly, these negative results from a relatively young sample of patients came as a surprise, when comparing the somewhat more positive results of the swan neck patients who had an older mean age. The main reason for this discrepancy most probably lies in the difference of the splints that were prescribed for the two deformities. It is also possible that in the younger patients the disease was still more active, causing faster changes. Sherrer et al (1986) reported that the fastest development of deformity takes place in the first five years after onset of the illness.

It would seem that the boutonniere deformity needed a more dynamic splint with more aggressive stretching than that which was prescribed. (see Chapter V for recommendations).

SUMMARY:

This study yielded very few statistically significant results. Certainly no definite answer was given to the question whether or not splints could prevent swan neck and boutonniere deformities.

The swan neck experimental group seemed overall to achieve better results than the control group. General tendencies seemed to indicate a shortening of volar soft tissue and more supple dorsal soft tissue in the experimental group compared to deterioration of the control group in that respect. The only significant difference to support this general trend was a decrease in active hyperextension of the PIP joint in the control group.

Loss of active flexion coupled with an increase in passive flexion in both experimental and control groups lead to the assumption that loss of muscle strength is a real threat to the hand function of all patients with RA. In contrast to this, active flexion was gained (not significant) by patients from the experimental group who had deformities of equal grade in both hands. This phenomenon could be explained by the patients' need to use the deformed hand if deformities of equal severity were present bilaterally.

As far as loss of muscle strength is concerned, it seemed possible that grade I swan neck deformities lost muscle strength because they wore the splint while people with grade II deformities lost less muscle strength as the result of wearing the splint. Although this does make theoretical sense, the findings were

not significant. "Socio-economic status" as well as "strain on hands" were ruled out as possible confounding variables influencing results.

The overall outcome of the boutonniere experimental group was less favorable than the outcome of the control group, although differences were not significant. These negative results were more evident in grade I than grade II deformities. After wearing the splint, patients from the grade I experimental group lost flexion as well as extension range of movement. This implies a stiffening of the joint, which could well be attributed to the splint (see Chapter II, p.59).

For both swan neck and boutonniere deformities the general tendencies were reversed when results were tested for the factor "compliance" in one way, and reversed back when results were tested for the influence of "compliance" in another way. This change in results could only be explained as being indicative of the influence that the large variability inherent in measurements, had on the results.

The swan neck and boutonniere experimental and control groups were comparable in terms of most of the possibly confounding variables. Consequently those factors could not be regarded as the cause of bias in the results. However, each of these possible prognostic factors added to the total variability of the measurements. This large variation, coupled with the relatively small subgroups of the sample, made it difficult to obtain statistically significant results (see "definition of terms" for the term "statistical power").

The weak test-retest reliability scores for flexion range obtained in the "range of movement" pilot study, stemmed most probably from inexperience of the rater in the beginning, which was corrected in the study itself. The consistent loss of active flexion throughout the study therefore cannot be attributed to these weak

results and consequently ignored. Weakening of muscles must be taken seriously as a possible negative side-effect of splinting.

CHAPTER V

CONCLUSIONS:

1. The aim of this study was to establish whether a splint programme is effective in preventing the worsening of already evident swan neck and boutonniere deformities in RA (Chapter I, p.2). The study did not prove that fewer patients treated with a splint programme than patients not treated with a splint programme experienced a deterioration in terms of **grade of deformity**, as was stated in the hypothesis (Chapter I, p.3). The follow-up time of one year was simply too short (Chapter II, p.37).

   Deterioration in deformity was however detected by means of a change in **range of movement** and the composite pattern of loss of range of different modalities of movement. Few results were significant.

   As far as swan neck deformity is concerned, the application of a splint had one significant positive outcome in shortening the volar soft tissue at the PIP joint (Chapter IV, p.138). The results of the boutonniere splint programme were significantly negative for grade I deformities with a loss of flexor muscle strength and more laxity of the dorsal structures of the PIP joint (Chapter IV, p.150).

   The aim was therefore only partly reached. The option of a longer time for follow up to allow more dramatic results was discarded, mainly for two reasons:

(1) Compliance of patients dropped to 26% and 32% for the two deformities after one year.

(2) The ethical question as to the possible negative side-effects of splinting was raised in individual patients when the fingers splinted seemed to become stiff.

From the evidence in this study it can be concluded that a positive outcome is possible when the PIP hyperextension splint (Fig.8, p.46) is used for swan neck deformities. Futhermore, the adjusted three-point PIP extension splint (Fig.14, p.58) was found to be unsuitable to prevent boutonniere deformity and should be avoided in a grade I boutonniere deformity (Chapter IV, p.152)

The above significant findings were supported by statistically insignificant but apparent tendencies in most instances. A factor which was present in all the analyses, but only significant for grade I boutonnieres, was a loss of flexor muscle strength.

As was suggested by the literature (Chapter II, p.77) and confirmed by the results (Chapter IV,p.159), the main reason for the lack of significance in the result, was the large variability encountered in the measurements.

The findings of this study have been combined with information from the literature in chapter II in order to devise a master plan. This has been presented in the form of "recommendations" (see later, p.164).

2. Several of the secondary objectives of this study (Chapter I, p.3) were reached:

2.1 Theoretical bases for the prevention of swan neck and boutonniere deformities through the medium of splinting were established. These were achieved by combining the insight into the pathological processes at play in the deformities (Chapter II, p.22-35) with the significant results as well as the tendencies. Although this master plan (see recommendations) has by no means been proven to be successful, it is suggested as an alternative to the less specific suggestions currently recommended in the literature (Chapter II, p.44).

2.2 The objective, to isolate the factors which could influence the development of the deformities, was largely reached through the literature review (Chapter II, p.17-20, 60, 75). The strain that people place on their hands through their lifestyle was considered such a factor. An instrument to measure this was developed and found to be useful (Chapter III, p.88). Further refinement of this tool should still be undertaken. A distinction between bilateral and unilateral activities should be made, coupled with a recording of the amount of strain on each hand separately. The instrument failed to register whether any patients used the better hand to perform activities if one hand was more deformed than the other. It is also theoretically possible to determine more accurately the force and range of movement each activity would require as well as the length of time a static grasp would last for each activity. This would enable the researcher to add a numeric value to each modality of movement associated with an activity. The regularity of performance of the activity should also be incorporated. Ultimately standardisation should be pursued.

2.3. The validity of using joint range measurements to confirm the status of the deformity was deduced from the descriptions of the grades of deformity (Chapter II, p.32 and p.35). The concept of a composite picture of joint range modalities was developed (Chapter IV p.138 and p.150) to describe the status of the deformity as an entity. It may be possible to redefine the grading systems for swan neck and boutonniere deformities in more detail by incorporating this concept. An undertaking of this nature would demand accurate documentation of development of deformities over several years.

The reliability for measurement of flexion of the PIP joint was weak. Although only a small sample was used in the pilot study, the results are warning enough that even when a normal PIP joint is measured by the ENRAF goniometer, the MP joint should be kept in extension (Chapter IV, p.146).

RECOMMENDATIONS:

Two issues should be addressed by the occupational therapist when considering the use of splints for the prevention of boutonniere deformities. The first is: Is it ethical to prescribe a splint without conclusive evidence that the splint will do more good than harm? Secondly: If splinting is chosen as an option, when should splinting be considered and what should the splinting programme include?

I TO SPLINT OR NOT TO SPLINT:

The results from this study were fairly inconclusive as to what the patient may gain by wearing the prescribed splints. A possibilitiy exists that the splints might have contributed to the loss of muscle strength in some instances. Compliance in wearing the splint dropped in the swan neck subsample by 45%

and in the boutonniere subsample by 31% in the course of one year, but the deforming forces take their effect on the RA joint for years (Chapter II, p.18). It could be unethical to prescribe these splints indiscriminately to patients with a swan neck or a boutonniere deformity, because success could not be guaranteed and the splints might add to the loss of muscle strength. The patient could have more to lose than to gain, unless all the time and money spent is not in any case wasted because the patient decides not to wear the splint.

Nevertheless, splinting may have a role to play in the prevention of deformities if chosen correctly, applied at the right moment in the development of the deformity, accompanied by the apporpriate parallel treatment and monitored and adapted as and when the situation changes. To be able to do the above, it is not enough to identify the deformity as a swan neck or boutonniere and prescribe a splint. The exact biomechanical basis of the deformity of the specific patient must be ascertained, and treatment custom made for the patient according to the obtained results.

II SUGGESTED MASTER PLAN FOR TREATMENT OF SWAN NECK AND BOUTONNIERE DEFORMITIES THROUGH SPLINTING

1 SPLINTING SWAN NECK DEFORMITIES:

1.1 If confronted by a possible swan neck deformity, the therapist must investigate whether the deformity is indeed a swan neck deformity, or whether the patient has congenitally lax joints. The definition of swan neck deformities can be used. (see "Definition of Terms", p.XVI)

1.2 When a swan neck deformity is positively diagnosed, it must be graded according to the system described earlier (Chapter II, p.32). The system is also used for the plan outlined below.

1.3 A grade III swan neck deformity should not be splinted, unless splinting would make the hand more functional. In practice, this is hardy ever achieved. Furthermore, it is very difficult to manufacture a splint for a grade III deformity, where the constant force in the direction of hyperextension must be resisted constantly without squashing the splint. The patient finds it difficult to put the splint on and take it off from a grossly deformed finger. It is further recommended that a stiff swan neck's X-ray films be examined because it is of no avail to splint an ankylosed joint!

1.4 When a grade II deformity is diagnosed, the specific soft tissue abnormalities present must be carefully considered.

1.4.1 If intrinsic tightness is perceived to play a major role in the grade II deformity, it is probably better to focus treatment on relief of this tightness (Chapter II, p.23). This could be achieved by decreasing effusion near the intrinsic muscles by resting the MP joint, combined with gentle stretching of the intrinsic muscles, by keeping the MP joints in extension and allowing full PIP and DIP flexion (Chapter II, p.24). The patient could wear this splint at night and still be able to grasp hold of blankets using a hook grasp. The active flexion of PIP and DIP joints while grabbing the blankets, combined with the extended position of the MP joints held by the splint, will add to the stretching of the intrinsic muscles.

1.4.2 When damage to volar soft tissue in the form of stretched FDS tendons (Chapter II, p.29) or a stretched PIP volar plate with a large range of hyperextension is evident, the hyperextension splint used in the study, may have a positive effect (Chapter IV, p.142). If the long flexor is on the point of rupturing, the splint may help to avoid this tragedy. If the flexor is ruptured already, the splint may provide the stability necessary for function as was suggested by Philips (1989). The tendon will however not be cured by the splint. Instructions to the patient for wearing of the splint will depend on the reasons for prescription:

(1) if the splint has to protect the soft tissue, it must be worn when the danger of further damage is present. This will include times when the hands are being used in activities that cause strain, and if the patient has the habit of sleeping on his/her fingers or is restless while sleeping.

(2) if the FDS tendon has already ruptured, the splint would have to be worn for functional purposes during the day. In both instances an aggressive exercise program (Chapter II, p.42) for the muscles of the hand must accompany the splint. Patients should be warned of the possibility of loss of muscle strength (Chapter IV, p.140), especially if the splint is worn day and night.

1.4.3 If the grade II deformity is a snapping swan neck without any of the other soft tissue complications, treatment should be geared towards keeping the lateral bands of the extensor expansion in a position volar to the PIP joint axis (Chapter II, p.26). It is recommended that the therapist should re-evaluate after a few minutes whether or not the hyperextension splint is still keeping this position adequately. Without the maintainence of this position, positive results with the splint can not be anticipated on

theoretical grounds. Muscle strengthening exercises including both isotonic and isometric exercises (Chapter II, p.43) for the intrinsic (Chapter II, p.21) and extrinsic muscles (Chapter IV, p.139) will have to accompany usage of the splint.

1.4.4 When a mallet finger is the only sign of soft tissue involvement and the PIP joint seems to be reasonably well preserved, the only course of action necessary is a mallet finger splint (Chapter II, p.52). If the mallet finger is accompanied by any of the above soft tissue problems, one should first establish whether the mallet finger problem still exists after any other soft tissue problem has been solved. If the lateral bands of the extensor expansion have ruptured, splinting will have no effect and only hamper functioning.

1.5 If grade I swan neck deformity is diagnosed, and seems to be accompanied by intrinsic tightness, it will probably be wise to prescribe the intrinsic tightness splint (see 1.4.1). This would apply if the general progress of the disease in the patient seems to be rapid, because of the possibility that intrinsic tightness could lead to PIP involvement (Chapter II, p.23). The splint can easily be combined with a wrist resting splint if the wrist joints are swollen and painful.

Grade I swan necks should not be splinted until evidence of a deforming force in the specific patient's case can be identified. Loss of muscle strength seems to outweigh the gains that the splint may have (Chapter IV, p.141). The golden rule is: Do not splint unless you can defend your splint on specific biomechanical grounds for the specific patient.

2 SPLINTING BOUTONNIERE DEFORMITIES:

2.1 Care should be taken to discriminate between a boutonniere deformity and other deformities such as Dupuytren's contracture or familial congenital flexion deformities. The patient should also be questioned about any earlier injury, which may have caused a boutonniere deformity (Souter, 1974), the treatment of which is beyond the scope of this study.

2.2 If a boutonniere deformity from RA is diagnosed, the deformity should be graded according to the grading system (Chapter II, p.35).

2.3 A grade III deformity has a poor prognosis (Chapter II, p.35), and the patient may be better off spending his/her energy coping with everyday chores rather than wearing a splint. If the X-ray film indicates that some joint space still exists, and some extension could be gained when the PIP joint is stretched passively, a splint such as the dynamic figure-of-eight (Fig.9, p.48) could be used, if the patient can be monitored regularly for possible loss of flexion range.

2.4 A grade II boutonniere deformity should be assessed with the retinacular test (Chapter II, p.35). A negative retinacular test, indicating shortening of the Landsmeer ligaments, is an indication for a splint which can stretch the PIP joint into extension whilst the patient continues to flex the DIP joint actively. At the same time the flexion range of movement should be protected (Chapter IV, p.152). This could be achieved by the Capener splint (Fig.11, p.54), which would be better than the PIP extension splint that was used in this study, because it requires the PIP joint to flex against the spring wire of the splint. A patient wearing this splint should be carefully monitored for the possibility of a flare-up of the PIP joint

(Chapter II, p.55). Measuring the circumference of the PIP joint is an objective method of doing this.

2.5 The PIP joints with grade I boutonniere deformity in the study sample seemed to became stiff more easily than the grade II deformities (Chapter IV, p.152). This could be attributed to the choice of splint, but may also be because of other pathological reasons at play during an active phase of the illness. Another possible way of dealing with the grade I boutonniere is to engage the patient in exercises to specifically stretch the PIP joint whilst flexing the DIP joint. If it is difficult to achieve this through activity, the patient can be referred to physiotherapy for a set of home exercises.

3. FOLLOW-UP ASSESSMENT:

The success of the plan outlined above depends on regular follow-up assessments. At each visit the therapist must repeat the same thorough assessment and compare the results with the results of the previous visit. This comparison will indicate whether any deterioration or improvement has taken place. This implies detailed records of findings at each visit. Other possible explanations for change in the status of the deformity should also be recorded and kept in mind when the plan is altered. These factors could be: a general flare-up of all joints; change in medication; a change in the activity pattern of the patient (see above); the regularity with which the splint has been worn (see Appendix 1, p.185) and whether the exercises have been done. When assessing the activity pattern of the patient, the tool developed in the pilot study "strain on hands" (see Appendix 2, p.186) can be used until the new improved standardised version is available, but

it must be noted whether or not the hand with the deformity has been used in the performing of the activities.

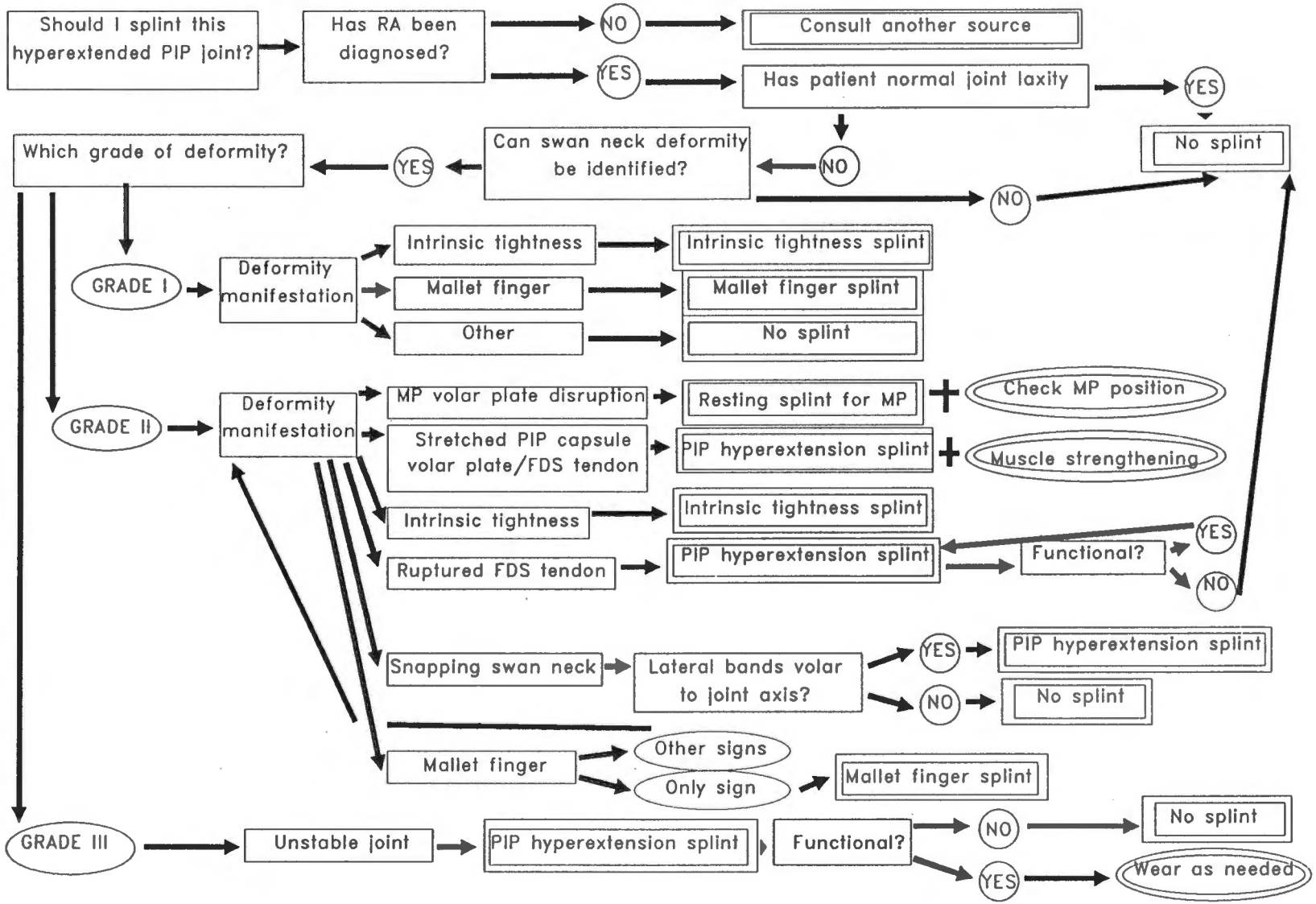
One is aware of the time pressure on the therapist in the clinical situation to decide on a splint strategy if confronted by a patient with a possible swan neck or boutonniere deformity. The recommendations outlined above are summarised in two flow diagrams, one for each deformity (see p.171 and p.172), to aid the therapist in this decision.

Although these recommendations have a sound theoretical basis and are tentatively substantiated by the findings of the study, the effectiveness of this master plan would still need to be studied through further research.

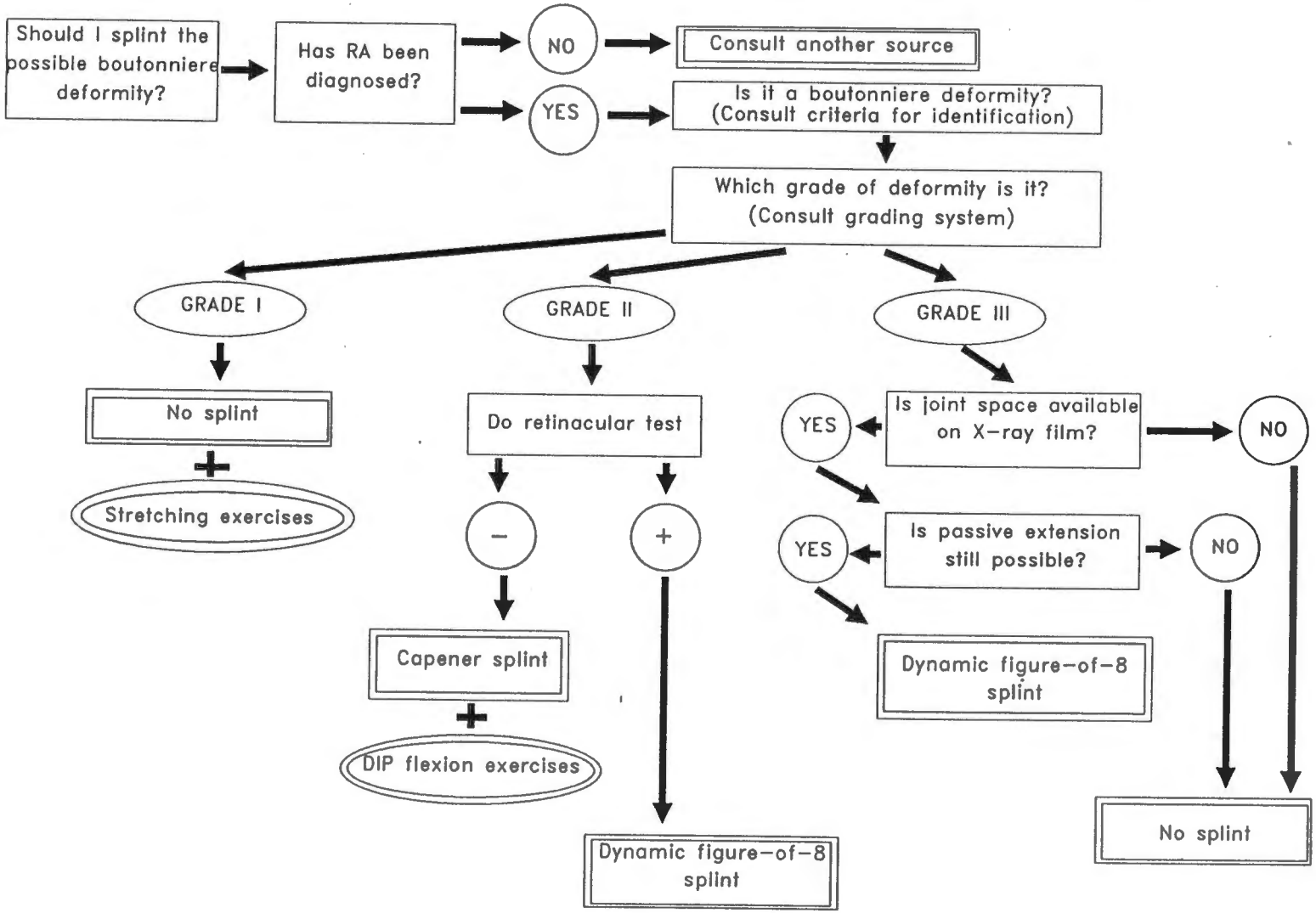
A few factors complicate the choice of study structure in such an endeavour. The most important one is that of the very individual nature of the solutuion to each patient's deformity. If the effect of each recommendation has to be substantiated, very small subsamples will be available. Another major problem is that the variation in the rate of development of the deformity might well depend on physiological factors of genetic or environmental origin.

The single system designs advocated by Ottenbacher (1986) presented a worthwhile possibility to investigate. This study method would suit the longitudinal nature of the study material. It would also allow treatment to be changed according to set criteria, for which the master plan could be used, to meet the needs of the individual patient.

FLOW DIAGRAM 1: TO HELP ONE DECIDE ON A SPLINT STRATEGY FOR A PROBABLE SWAN NECK DEFORMITY



FLOW DIAGRAM 2: TO HELP ONE DECIDE ON A SPLINT STRATEGY FOR A PROBABLE BOUTONNIERE DEFORMITY



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APPENDICES

APPENDIX 1

SPALKE VIR SWAANNEK EN BOUTONNIERE DEFORMITEITE - STUDIE

SIFTINGSVORM:

A: KAART NO _ _ _ | _ | 1
Pasient plakker — Pt. No. | _ | _ | _ | 4

Kliniek : Wes=1 Oos=2 | _ | 5

Ras en geslag kode | _ | 6
Ouderdom met aanvang(jr) | _ | _ | 8

Adres:.....

..... Poskode | _ | _ | _ | _ | 12
Tel. No. .....

Dominansie: Regs = 1; Links = 2 | _ | 13

Enige ander spalke wat pasient dra?
.....
.....

B: DEFORMITEIT:

Tipe: 0 = Afwesig
1 = Swaannek
2 = Boutonniere

Graad: I = 1
II = 2
III = 3

REGTERHAND: Vinger no 2.....Tipe | _ | 14
.....Graad | _ |
Vinger no 3.....Tipe | _ | 16
.....Graad | _ |
Vinger no 4.....Tipe | _ | 18
.....Graad | _ |
Vinger no 5.....Tipe | _ | 20
.....Graad | _ |

LINKERHAND: Vinger no 2.....Tipe | _ | 22
.....Graad | _ |
Vinger no 3.....Tipe | _ | 24
.....Graad | _ |
Vinger no 4.....Tipe | _ | 26
.....Graad | _ |
Vinger no 5.....Tipe | _ | 28
.....Graad | _ |

C: KEUSE VAN VINGER

VINGER IN STUDIE INGESLUIT: HAND Regs = 1
Links = 2 | _ | 30
VINGER NO 2,3,4,5 | _ |
DOMINANTE HAND Ja = 1
Nee = 2 | _ | 32

KONTROLE VINGER HAND Nvt = 0
Regs = 1 | _ | 33
Links = 2
VINGER NO 2,3,4,5 | _ | 34

PASIENT TOESTEMMING:

METINGVORMS - EKSPERIMENTELE VINGER

KAART NO		_ 1
METING NO		_ 2
DATUM	Dag/ Maand/ Jaar	_____ 8
EKSPERIMENTELE VINGER:		
(Merk toepaslike blokkie met x)		
HAND	Regs = 1 / Links = 2	_ 9
VINGER NO.	2 / 3 / 4 / 5	_
TIPE DEFORMITEIT	Swaannek = 1 / Boutonniere = 2 / Geen = 0	_ 11
GRAAD	I / II / III	_ 12
OMVANG VAN BEWEGING - GONIOMETER-LESING		
Dui posisie van omvang bereik aan nl. : hiperektensie :- 180 +		
reguit :- 180		
fleksie :- 180 -		
METAKARPOFALANGEALE GEWRIG:	Rusposisie	___ 15
	Passiewe ekstensie	___ 18
	Aktiewe ekstensie	___ 21
	Passiewe fleksie	___ 24
	Aktiewe fleksie	___ 27
PROKSIMALE IF GEWRIG:	Rusposisie	___ 30
	Passiewe ekstensie	___ 33
	Aktiewe ekstensie	___ 36
	Passiewe fleksie	___ 39
	Aktiewe fleksie	___ 42
DISTALE IF GEWRIG:	Rusposisie	___ 45
	Passiewe ekstensie	___ 48
	Aktiewe ekstensie	___ 51
	Passiewe fleksie	___ 54
	Aktiewe fleksie	___ 57

METINGVORMS - KONTROLE VINGER

KAART NO _ 1
METING NO ..... _ 2
DATUM Dag/ Maand/ Jaar _ _ _ _ _ _ 8

KONTROLE VINGER:

(Merk toepaslike blokkie met x)

HAND | Regs = 1 | Links = 2 | _ 9

VINGER NO. | 2 | 3 | 4 | 5 | _

TIPE DEFORMITEIT | Swaannek = 1 | Boutonniere = 2 | Geen = 0 | _ 11

GRAAD | I | II | III | _ 12

OMVANG VAN BEWEGING - GONIOMETER-LESING

Dui posisie van omvang bereik aan
nl. : hiperektensie :- 180 +
reguit :- 180
fleksie :- 180 -

METAKARPOFALANGEALE GEWRIG:	Rusposisie	_ _ _ 15
	Passiewe ekstensie	_ _ _ 18
	Aktiewe ekstensie	_ _ _ 21
	Passiewe fleksie	_ _ _ 24
	Aktiewe fleksie	_ _ _ 27
PROKSIMALE IF GEWRIG:	Rusposisie	_ _ _ 30
	Passiewe ekstensie	_ _ _ 33
	Aktiewe ekstensie	_ _ _ 36
	Passiewe fleksie	_ _ _ 39
	Aktiewe fleksie	_ _ _ 42
DISTALE IF GEWRIG:	Rusposisie	_ _ _ 45
	Passiewe ekstensie	_ _ _ 48
	Aktiewe ekstensie	_ _ _ 51
	Passiewe fleksie	_ _ _ 54
	Aktiewe fleksie	_ _ _ 57

ALGEMENE INLIGTING:

KAART NO. |_|1
METING NO ..... |_|2
DATUM Dag/ Maand/ Jaar |_|_|_|_|_|_|8

VERLOOP VAN SIEKTE EN BEHANDELING:

Huidige toestand van hande
1 = Aktief
2 = Effens aktief
3 = Onaktief

Teenwoordigheid van ulnere deviasie 1 = Ja 2 = Nee |_|9

Medikasie: |_|10
1 = Anti-inflamm.
2 = Stadigwerkende
3 = Ander
4 = Geen

Indien (2), datum van begin |_|11
|_|_|_|_|_|_|17
Spesifiseer 'ander':_____

Gebruik van hande
1 = Minder as gewoon
2 = Normaalweg
3 = Meer as gewoon |_|18

Stremmendheid van aktiwiteite
1 = Stremmend
2 = Gebalanseerd
3 = Nie-stremmend |_|19

Enige verandering in behandeling, t.o.v.:

	Ja=1	Nee=2	
Chirugie van hand			|_|20
Fisioterapie van hande			|_|21
Arbeidsterapie			|_|22
Enige ander spalke			|_|23

Spalk se voorkoms:

	Ja=1	Nee=2	
Vuil			|_|24
Verkleur			|_|
Glad geskuur			|_|26
Besig om te verbrokkel			|_|
Gebuig			|_|28
Gebreek			|_|

GETROUHEID VAN SPALKDRA:

Omsirkel die antwoord van u keuse bv. (1)	
(a) Wanneer het u die spalk gedra?	
1. snags	
2. soms snags, soms bedags	
3. meesal bedags	
4. nooit gedra nie	_|29
(b) Hoe lank aaneen het u die spalk gedra?	
1. minder as 1 uur.	
2. 1 tot 5 uur	
3. 5 tot 8 uur	
4. langer as 8 uur	_|30
(c) Hoeveel uur per dag het u die spalk gedra?	
1. Geen	
2. minder as 1 uur	
3. 1 tot 5 uur	
4. 5 tot 8 uur	
5. 8 uur en meer	_|31
(d) Gemiddeld hoeveel van die 30 dae in 'n maand het u spalk wel gedra? .....dae	_|_|33
(e) Het die spalk u gedruk? (Ja=1;Nee=2)	_|34
(f) Was die spalk ongemaklik? (Ja=1;Nee=2)	_|35
(g) Het die spalk gebreek? (Ja=1;Nee=2)	_|36

APPENDIX 2:

CHECKLIST FOR MEASURING STRAIN ON JOINTS

INSTRUCTIONS:

1. Identify the activities that you perform regularly (i.e. three times a week or for lown mowing or pruning once a fortnight)
2. Circle all the *'s against the activity you perform regularly.
3. Add up all the circles in each column.
4. Total the first 4 columns and the last 4 columns as well as the grand total.
5. Interpret against the norm. (See Table 12, p.90)

ACTIVITY	DYNA-MIC GRASP	LIGHT MOVE-MENT	INNER JOINT RANGE	PRECI-SION GRASP	STATIC GRASP	FORCE MOVE-MENT	OUTER JOINT RANGE	POWER GRASP
Eating		*	*	*	*			
Dressing	*	*					*	*
Washing	*	*					*	*
Into/out of bath					*	*	*	*
Driving a car					*	*	*	*
Shopping	*				*	*	*	*
Using telephone	*	*	*	*	*			
Writing		*	*	*	*			
Typing	*	*	*	*				
Using hand tools			*		*	*		*
Operating machines					*	*	*	*
Using spade/shovel					*	*	*	*
Mowing lawn			*		*	*		*
Pruning shrub/tree			*		*	*		*
Weeding	*	*	*	*				
Peeling apples etc.		*	*		*			*
Handling pots/pans			*		*	*		*
Washing dishes	*	*	*			*		*
Making beds	*					*	*	*
Vacuuming/Sweeping			*		*	*		*
Beating/Grating			*	*	*	*		*
Opening bottle/tap			*		*	*	*	*
Knitting		*	*	*	*			
Crocheting		*		*	*		*	
Machine sewing	*	*	*	*				
Using scissors	*		*	*		*		
Hand sewing		*		*	*		*	
Reading	*	*	*	*				
Playing cards	*	*	*	*	*			
Boardgames	*	*		*			*	
Playing the piano	*	*						
Playing guitar				*	*	*	*	*
TOTAL								
NON STRENUOUS ACT.					STRENUOUS ACTIVITY			
					TOTAL STRAIN LEVEL			

AKTIWITEITE VIR R.A. PASIENTE - 'N ONTLEDING

AKTIWITEIT	DINAMIESE GREPE	LIGTE BEWEGING	BINNE OMVANG	PRESISSIE GREPE	STATIESE GREPE	KRAGBEWEGINGS	BUITE OMVANG	KRAGGREPE
Eet		x	x	x	x			
Aantrek	x	x					x	x
Was	x	x					x	x
In en uit bad klim					x	x	x	x
Motor bestuur					x	x	x	x
Inkopies doen	x				x	x	x	x
Telefoon gebruik	x	x	x	x	x			
Skryf		x	x	x	x			
Tik	x	x	x	x				
Hantering van handgereedskap			x		x	x		x
Hantering van groter masjiene					x	x	x	x
Hantering van grawe, pikke,ens.					x	x	x	x
Grassny			x		x	x		x
Snoei			x		x	x		x
Onkruid uittrek	x	x	x	x				
Groente skil		x	x		x			x
Kastrolle hanteer			x		x	x		x
Skottelgoed was	x	x	x			x		x
Beddens opmaak	x					x	x	x
Stofsuig/Uitvee			x		x	x		x
Klits/Rasper			x	x	x	x		x
Bottels/Krane oopmaak			x		x	x		x
Brei		x	x	x	x			
Hekel		x		x	x		x	
Stik met naaimasjien	x	x	x	x				
Knip met sker	x		x	x		x		
Handmaaldwerk		x		x	x		x	
Lees	x	x	x	x				
Kaartspele	x	x	x	x	x			
Bordspele	x	x		x			x	
Klavierspeel	x	x						
Kitaarspeel				x	x	x	x	x
TOTAAL								

OPSOMMING:

APPENDIX 3:

METODE VAN EWEKANSIGE TOEKENNING AAN GROEP A OF B

1. Kry 'n aantal ewekansige nommers uit 'n sakrekenaartjie. Ewe-getalle word tentatief aan groep A en onewe getalle word tentatief aan groep B toegeken. Vul die toekennings in in die gegewe kolom.

2. Stel die TIPE en GRAAD van deformiteit vas en vul al die swaannekke op een vorm en al die boutonniers op 'n ander vorm in. Vul dan die graad van deformiteit in in die gegewe kolom.

3. Vul die kliniek (oos of wes) in in die gegewe kolom.

4. Om die 'D' kolom in te vul:
   Kyk na die GRAAD van deformiteit wat die persoon nou onder oorweging het.
   Trek die getal wat reeds aan groep A toegewys is (met die graad van deformiteit onder bespreking) af van die getal persone (met die betrokke graad van deformiteit) wat reeds aan groep B toegewys is.
   Hierdie verskil word in kolom 'D' ingevul.

5. Indien D kleiner as 2 is, word die tentatiewe toekenning oorgedra na die finale toekenning-kolom en indien D groter as 2 is, word die alternatiewe toekenning in plaas van die tentatiewe toekenning gemaak.

6. Dra hierdie toekenning onmiddellik oor op die siftingsvorm.

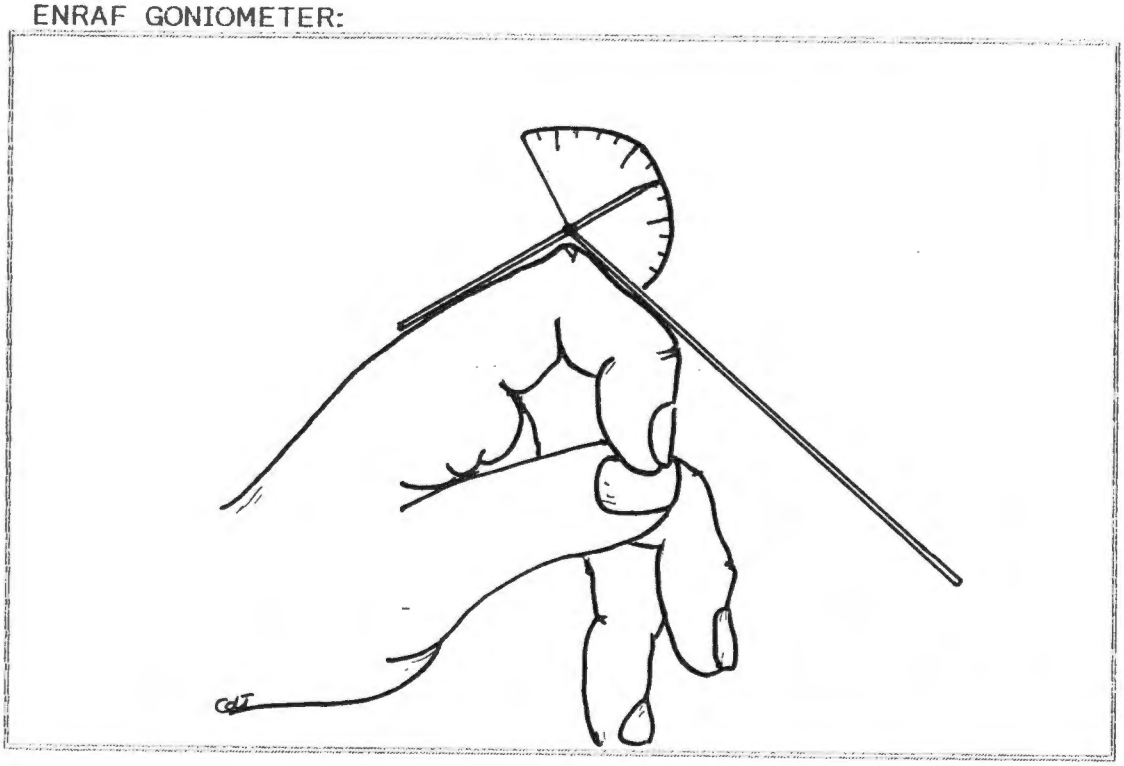
EWEKANSIGE TOEKENNING AAN EKSPERIMENTELE / KONTROLE GROEPE

Pt. No		Tentatiewe Toekenning	Kliniek Oos/Wes	Graad	D	Finale Toekenning	
001		A	O	I	1	A	
002		B	O	I	O	B	
003		A	O	II	1	A	
004		B	O	I	1	B	
005		B	W	II	O	B	
006		B	W	II	1	B	
007		A	W	I	O	A	
008		A	W	I	1	A	
009		B	W	I	O	B	
010		A	O	II	O	A	
011		A	O	II	1	A	
012		A	O	I	1	A	
013		B	O	II	O	B	
014		B	O	II	1	B	
015		A	W	I	2	B	*
016		B	W	II	2	A	*
017		B	W	I	1	B	
018		B	W	I	2	A	*

APPENDIX IV

MEASUREMENT OF PIP JOINT RANGE

ENRAF GONIOMETER:



METHOD FOR MEASURMENT USED IN STUDY:

1. POSITION OF PATIENT:

1.1 The patient is sitting at a table with the elbows supported on the table.

1.2 The therapist sits facing the patient.

1.3 Severely handicapped patients may not be able to assume this position. In this case the patient may rest the elbow on the armrest of the wheelchair and the therapist stands bending over to the patient.

2. TO MEASURE RESTING POSITION:

2.1 INSTRUCTION TO THE PATIENT:

"Do not move your fingers now. Just relax your hand. I am holding it"

2.2 STABILIZATION:

Support the hand in the palm controlling also the wrist.

2.3 ALIGNMENT OF GONIOMETER:

Place the goniometer on the dorsum of the finger with the goniometer joint on the PIP joint.

With a swanneck deformity the PIP joint may rest in a hyperextended position which demands alignment on the ventral aspect of the finger.

It is easier to control the hand and the goniometer with the long end of the goniometer on the middle phalanx and the short end on the proximal phalanx.

2.4 RECORDING OF MEASUREMENT:

Read the measurement on the protractor along the long flat edge of the pointer. Record the measurement to the nearest five degrees. Ask the patient, if necessary, to relax to take a final measurement.

3. MEASUREMENT OF ACTIVE EXTENSION:

3.1 INSTRUCTION TO THE PATIENT:

"Make your finger as straight as possible". "If you find it easier, you may stretch your other fingers as well"

3.2 STABILIZATION:

The same as above (see 2.2) and the therapist stabilize the short hand of the goniometer and the proximal phalanx together in a three-point grasp.

3.3 ALIGNMENT OF GONIOMETER:

For a swan neck deformity, the goniometer is placed on the vertral side and for a boutonniere deformity on the dorsal side of the finger. Align further as above (see 2.3).

Ask the patient for his/her best attempt and push the long hand of the goniometer gently to lie parallel with the long axis of the middle and distal phalanges.

3.4 RECORDING OF MEASUREMENT:

(See 2.4)

4. MEASUREMENT OF PASSIVE EXTENSION:

4.1 INSTRUCTION TO THE PATIENT:

"Relax your hand, I am going to do the movement for you".

4.2 STABILIZATION:

(See 3.2)

4.3 ALIGNMENT OF GONIOMETER:

Align as for active extension. Do the passive movement by pushing against the long end of the goniometer until just before the joint of the goniometer starts to seperate from the PIP joint. If the goniometer is allowed to seperate from the finger, too large a range of movement will be recorded.

4.4 RECORDING OF MEASUREMENT:

As above. Repeat at least twice to get the maximum reading.

PLEASE NOTE: A fixed MP or DIP flexion deformity may make alignment as it was discussed impossible. In this case the two hands of the goniometer must be aligned laterally but still ventral to the finger along the long axes of the phalanges.

5. MEASUREMENT OF ACTIVE FLEXION:

5.1 INSTRUCTION TO THE PATIENT:

"Bend your fingers as far as possible, concentrating on this one (point) which I am going to measure."

5.2 STABILIZATION:

If the patient has long finger nails as well as a large range of movement, keep the MP joint in a more extended position to keep nail from digging into the palm of the hand.

5.3 ALIGNMENT OF GONIOMETER:

Place the goniometer as for extension but on the dorsal surface of the finger.

5.4 RECORDING OF MEASUREMENT:

As for active extension.

6. MEASUREMENT OF PASSIVE FLEXION:

6.1 INSTRUCTION TO THE PATIENT:

"Relax your hand, I am going to do the movement for you".

6.2 STABILIZATION:

As above.

6.3 ALIGNMENT OF GONIOMETER:

Stabilize the short hand on the proximal phalanx with a three-point grasp and the long hand on the middle phalanx with a three-point grasp. In this way the position of the MP joint can also be controlled by the therapist.

6.4 RECORDING OF MEASUREMENT:

As for passive extension

APPENDIX 5

FABRICATION AND FITTING OF SPLINTS:

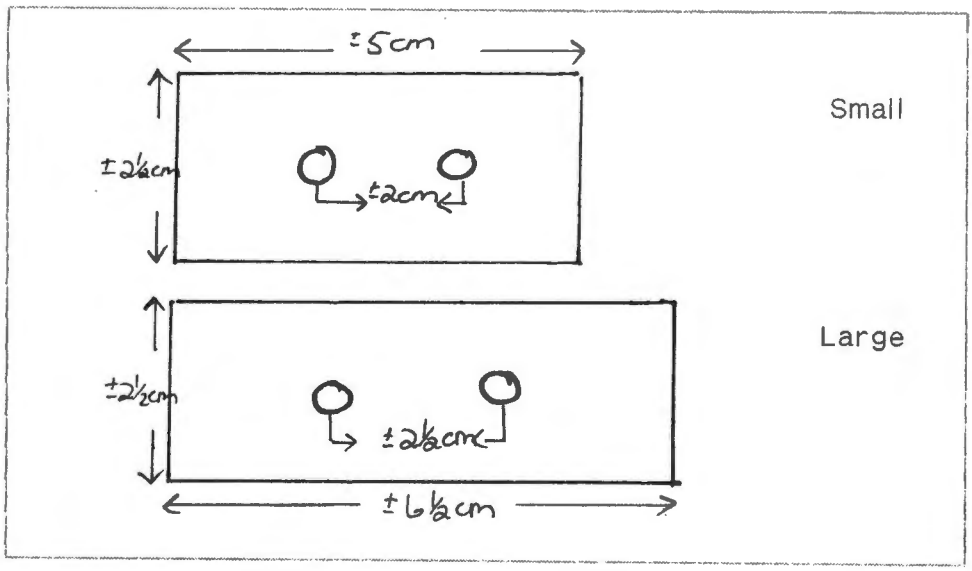
I PIP HYPEREXTENSION SPLINT

(See Fig.8 page 46)

MATERIALS: San-splint XR supplied by Smith and Nephew Inc.

EQUIPMENT: Electric frying pan (or equivalent) able to control the temperature.
Scissors
Towel
Electric drill or leather punch. The latter is taxing on the therapist's hands.

PATTERN: The sizes do not have to be exact. Keep an assortment of different sizes, and pick the best size for the finger of the patient. Drill all the holes beforehand.



FABRICATION

1. Heat the water in the frying pan to 60 degrees Celcius

2. Emerse the piece of Sansplint in the water for a few seconds until it is soft enough to form but not overheated.

   PLEASE NOTE: An overheated splint will shrink on the patient hand while it cools down and patient will struggle to remove the splint. Do not try to re-use overheated Sansplint.

3. Stretch the holes in the width (not the length) until a slit large enough for the finger is formed.

4. Grab one end at each side of the hole with the rest hanging downwards.

5. Push the finger through the top hole to just proximal to the PIP joint. Urge the patient not to try and help but to relax the finger.

6. Push the finger through the bottom hole. The two edges sticks out dorsally and ventrally a loop is formed. Take care that the ventral band moves freely, if not stretch the holes a little more in the width.

7. Bend the PIP joint PASSIVELY (patient stays relaxed) to the desired degrees of flexion (10-20). Fold the lateral ends ventrally and smooth the two dorsal parts over the proximal and middle phalanx.

8. When the required position is achieved, keep the position until the splint is firm but not totally cooled down.

9. Mark the excess material on the dorsum, to leave two neat, rounded bands which will not impede on MP or DIP movement, and mark ventrally all the lateral parts which will impede on PIP flexion.

10. Take the splint off before it has set totally without disturbing the form. Patient must relax.

11. Trim the excess on markings.

12. Smooth the cut edges by warming a millimeter of the edge and running a finger along the edge.

FITTING:

1. Ask the patient to put the splint on by him/her self, keeping the PIP slightly flexed.

2. Ask the patient if any discomfort is experienced.

3. Check that die PIP flexion is maintained.

4. Check that the dorsal parts form a smooth gutter for the finger with no sharp edges.

5. Check that full flexion range can be achieved.

6. Ask the patient to take the splint off. Assess the patient's ability to do this independently.

7. Make sure the patient knows how to fit the splint correctly.

8. Leave the splint on the finger while discussing instructions for wearing and check again for comfort.

GENERAL:

1. Do not try to reheat an overheated or stretched splint. The results are never satisfactory.

2. Warn the patient about the effects of heat on the splint.

3. Make an extra splint for the patient in case of loss or breakage before the next appointment.

II THREE-POINT PIP EXTENSION SPLINT:

(See Fig.14 page 58)

The instructions for the splint from the article by Callahan and McEntee (1986) were followed except in a few instances.

MATERIALS: The straps were made from Velcro and not tape to enable the patient to adjust the tension at home.

FITTING: The distal strap was positioned proximally to the DIP joint (p.57).